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The SCIENTIFIC MONTHLY

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Photo by Bureau of Plant Industry, Soils, and Agricultural Engineering, U.S.D.A.

EASTER LILIES IN SOILLESS CULTURE AT BELTSVILLE, MARYLAND

See *Growing Plants without Soil,* page 273.

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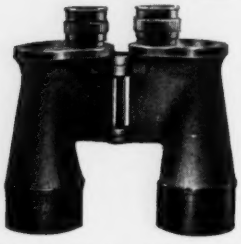

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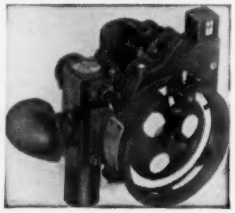

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THE SCIENTIFIC MONTHLY

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THE
SCIENTIFIC MONTHLY

APRIL 1948

GROWING PLANTS WITHOUT SOIL

NEIL W. STUART

Educated at Michigan State College and the University of New Hampshire, Dr. Stuart worked for a time at the New Hampshire Experiment Station. In 1932 he went to the University of Maryland on a fellowship and took his Ph.D. in plant physiology there in 1934. Since 1936 he has been with the U.S.D.A. and is now senior physiologist in the Division of Fruit and Vegetable Crops and Diseases, Bureau of Plant Industry, Soils, and Agricultural Engineering, Beltsville, Maryland.

THE possibility of growing plants without soil interests many people throughout the world. They include not only the commercial grower of flowers and vegetables, but the amateur as well. The home gardener, the city apartment dweller, the retired businessman, the disabled war veteran, the would-be promoter, all these and many others write thousands of letters asking for detailed instructions on growing tomatoes and orchids (these crops lead in interest), strawberries and cucumbers, gladioli and vanilla beans. Apparently, most of these letters are written with the best of intentions, an actual desire for information. Probably the number who make any use of the information so obtained is much smaller. Few of these people seem to realize that little or no information is available about many of their questions.

One of America's best-known plant physiologists, Dr. John W. Shive, has traced the development of our information on nutrition and methods of growing plants. His review, published in 1940,[17] divided the interval after 1700 into four periods ending in 1800, 1860, 1900, and 1940, respectively. A fifth period may now be added, beginning about 1929 and extending to the present time.

Each is marked by significant findings. Prior to the eighteenth century it was commonly believed that ". . . for nourishment of vegetables the water is almost all in all; . . . the earth only keeps the plant upright."[22] Had not van Helmont's willow, grown for five years in an "earthen vessel" containing 200 pounds of soil to which nothing was added except rain water or distilled water, produced a tree weighing 169 pounds at an expenditure of only 2 ounces of soil? An Englishman, John Woodward, disagreed with this opinion and published[22] in 1699 that "earth and not water is the matter that constitutes vegetables." His conclusion was based upon experiments in which he grew spearmint in glasses containing water from various sources, methodically recording the initial and final weights of the plants and the total amount of water consumed. He observed that the addition of an ounce and a half of garden soil to the water increased the "terrestial matter" and consequently the growth of the plants. As is the case with most research, original findings are often

accepted with reluctance. In 1734 this engaging title appeared: *A Flower Garden for Gentlemen and Ladies; being the Art of Raising Flowers Without any Trouble, to blow in full perfection in the depth of winter, in a Bedchamber, Closet or Dining Room . . . As practised by Sir Thomas More, Bart.* (London, 1734).

During the seventeenth century an increasing awareness of the role of soil as a source of plant nutrients introduced the studies on ash assimilation in the next period. Methods of growing plants in water or artificial soils were published from 1860 to 1900, followed, at the turn of the century, by further development of solution formulas and study of nutrient deficiencies. Serious attempts at substituting soilless culture for crop production have taken place only during the past two decades and were, as we shall presently see, stimulated immeasurably by the second world war. In the late twenties, growing plants in jars of water or crocks of sand was a standard experimental method in plant physiology, but it seemed to have little commercial application. True, the greenhouse industry near the cities was annually experiencing increasing difficulty in obtaining adequate amounts of manure and suitable soil for use in their beds and benches. Much labor is also involved in handling soil in greenhouses and in growing plants in soil. These problems encouraged a few research workers to substitute ordinary builders' sand for soil and manure and to rely on application of fertilizers dissolved in water for growing the plants. In 1928 Robbins, working at the New Jersey Experiment Station, had suggested[15] the possibilities of sand culture for research and commercial work in horticulture, following extensive trials with vegetables and fruit-tree seedlings. At the same time Biekart and Connors, also of the New Jersey Station, predicted that "the possibility of growing carnations commercially in sand is not remote." A later publication by these men stated that the production of quality carnations in sand with nutrient solution and in quantities comparable with those grown in composted soil seems to be thoroughly practical and economical.[2] At Ohio State University, Laurie described the use of washed sand as a substitute for soil in greenhouse culture of ornamentals.[10] Recently, Robbins has reviewed the whole question of growing plants in sand cultures for experimental work.[16] It is in this field rather than that of commercial production that sand culture has been most useful. Many laboratories for nutrition research in agronomy and horticulture have profitably investigated problems of nutrient deficiency and balance by means of sand culture tests. The failure of this method to attract commercial attention may be attributed to inertia of the industry, lack of information about specific problems such as media, time and amount of nutrient application, etc., and the need for a better system of soilless culture.

The other possibility, that of growing plants in water, was actively championed at about the same time by Dr. W. F. Gericke in California.[7] His enthusiasm for "hydroponics" made thousands of converts, and the growing of plants in water became the victim of extravagant and sometimes unscrupulous propaganda. In its original form the installation for hydroponics consisted of a shallow basin, tank, or trough partially filled with water and dissolved nutrients and covered with wire netting. The netting was covered with a layer of some such material as wood shavings, straw, salt hay, rice hulls, or even soil. The plants were grown in this layer with some of their roots extending into the nutrient solution below. The mulching material maintained a high humidity around the root crown of the plant and supported the growth of feeder roots that could absorb oxygen. Originally, the nutrient solution was not artificially aerated. Since the nutrient solution supplies oxygen as well as nutrients and water to the plant and since only relatively small quantities of oxygen are soluble in water, lack of it undoubtedly was often a limiting factor in plant growth. It is now recognized that if plants are to be successfully grown in water culture some means of aerating the solution, either by circulating it with a pump that mixes air with it or by forcing air into the solution through perforated

pipes, is imperative.[8] There are other rather obvious difficulties in using the method, such as the problem of supporting the plants and maintaining suitable nutrient balance. In experienced hands the method is capable of producing crops on a par with similar crops grown by conventional soil methods. Superior production by water culture is scarcely to be expected, and unless all precautions are observed crop yields may be much reduced below soil yields.

INTEREST in soilless culture might have declined had it not been for the development of a new method of applying water and nutrients to the plants. In this, the subirrigation method of culture, watertight beds or benches are filled with gravel or other suitable inert material, which is irrigated from the bottom of the bed. This system, in its simplest form, was conceived independently during the same year at the New Jersey and Indiana Agricultural Experiment Stations.[5,21]

Irrigation is accomplished by pumping the nutrient solution from the storage tank or cistern into the bench, the bottom of which slopes slightly from the sides to the middle and also lengthwise to the point where the solution enters and subsequently leaves the bench. Inverted half-round clay tiles or boards nailed together to form an inverted V are placed end to end lengthwise along the middle of the bench and serve as a channel for the solution. When the solution has nearly filled the bench, the pump is stopped and the solution drains back to the tank by gravity. In the newer benches built for subirrigation, a solution channel is formed by making a longitudinal depression along the lowest part of the floor "valley." The channel thus formed is covered with bricks or slabs of concrete provided with drainage holes at the sides. To facilitate rapid drainage these holes are covered with coarse gravel. This is known as the direct-feed system and is useful in greenhouses or small units. For larger installations it is more economical to employ the gravity-feed system. The beds or benches are built in series of 3 or 4 sections, each on a higher elevation and slightly longer than the one following it. Two solution

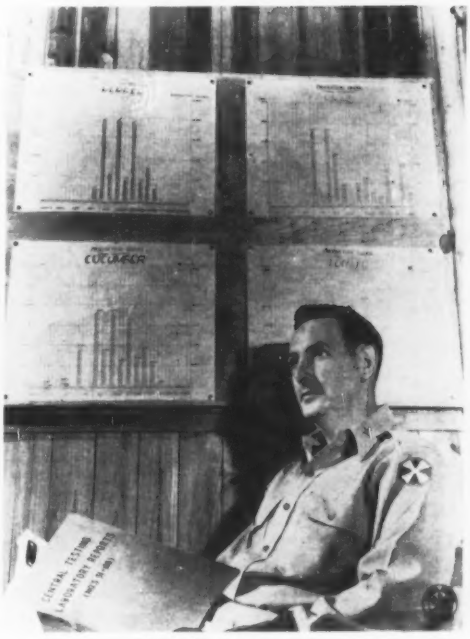


Photo by Signal Corps, U. S. Army

FIG. 1. LT. COL. EWING W. ELLIOTT
DIRECTOR OF HYDROPONICS, FAR EAST COMMAND.

tanks are used in this system. The larger one is located at the lower end of the beds and is below the bed level. It is connected with a somewhat smaller tank above the level of the beds. The smaller tank should have a capacity approximately one-half the total volume of the first sections of all the series. The nutrient solution flows into the first sections of the several series by gravity and then successively through the other sections, finally emptying into the sump tank. By this means only the solution for irrigating the first sections of the series has to be pumped, gravity flow irrigating the rest of the sections. The solution in the sump tank is analyzed, reinforced with the necessary chemical nutrients, made to volume, and pumped into the elevated tank in preparation for the next irrigation. Eastwood has described a modification of this construction known as the open-flume system, which was originated by Carroll Klotzbach in Florida.[6] All the solution is carried to and from the beds by means of a flume, so that no piping or valves are necessary except at the pump. The nutrient solution is stored in an above-

FIG. 2. SOILLESS RADISHES FOR THE U. S. ARMY IN JAPAN

JAPANESE WORKERS HARVEST A CROP GROWN AT THE 8002ND HYDROPONIC FARMING DEPOT, CHOFU, NEAR TOKYO.

ground tank, with a small sump tank for the pump, or a belowground cistern.

Interest in this subirrigation method of soilless culture was increasing rapidly at the outbreak of the second world war. Resultant shortage of construction materials and nutrient chemicals curbed further expansion by private individuals. Interest in the method was stimulated in another manner, however. In 1944 General H. H. Arnold, Commanding General, Army Air Forces, observed the soilless culture activities at the AAF Regional and Convalescent Hospital (now Pratt General Hospital) at Coral Gables, Florida, in connection with the AAF rehabilitation program. He became interested in the possibility of utilizing this method for supplying AAF personnel with fresh vegetables at isolated bases.

The first installation was established on Ascension Island, an isolated island in the middle Atlantic, early in 1945. This plant consisted of 25 beds 400 feet long and 3 feet wide; it was irrigated with distilled sea water. The yield of fresh salad vegetables, cucumbers, tomatoes, radishes, lettuce, and green peppers, during the first year of operation, was 94,000 pounds.

In the summer of 1945, 75 beds were constructed at Atkinson Field, British Guiana. Production of vegetables at this installation in 1946 amounted to 234,337 pounds. Costs of production ranged from 4 cents a pound for cucumbers to 22 cents a pound for peppers.[20]

A third soilless culture garden (the Army refers to them as "hydroponics" even though subirrigation is implied) was constructed on Iwo Jima in the summer of 1945 and began operation in November of that year. In the same month it was decided to establish two hydroponic garden projects in Japan, with a total area of 80 acres. This decision was reached because of the difficulty of providing highly perishable vegetables over extended supply lines, with the heavy shipping losses involved. It is known that much of the Japanese soil is contaminated, and it was considered unsafe to serve uncooked soil-grown vegetables to United States troops.

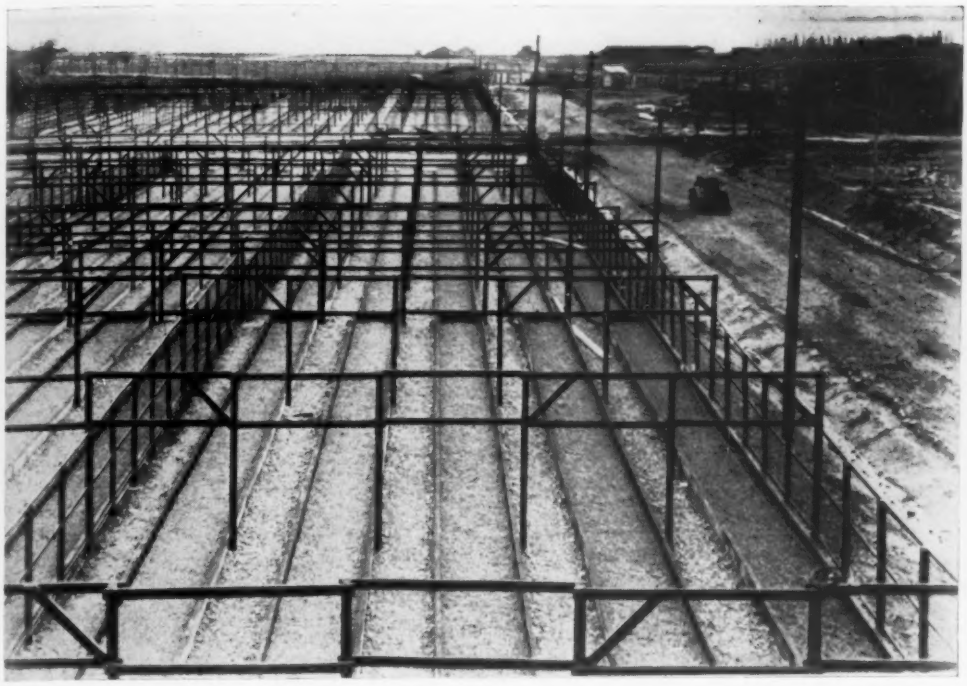


FIG. 3. CONSTRUCTION OF A 5-ACRE HYDROPONIC UNIT AT OTSU, NEAR KYOTO

THE WATER NEEDED FOR THIS PROJECT WILL BE DRAWN FROM LAKE BIWA, WHICH LIES IN THE BACKGROUND.

Lt. Col. Ewing W. Elliott, an Air Force Quartermaster officer, was appointed supervisor of the two Japanese Hydroponic Garden Projects, and he deserves much credit for planning the construction and directing the operation of this vast enterprise (Fig. 1).

The Japanese soilless culture gardens are constructed in units of 5 acres. Each unit contains 87 beds 300 feet long and 4 feet wide. The first section of each bed is 120 feet long; the second, 100; and the third, 80 feet. One of these units, at Chofu, near Tokyo, is under glass; the remaining 10 units at this location and 5 units at Otsu are in the open (Figs. 2, 3). It was expected that more than 10,000,000 servings of fresh vegetables would be produced during 1947.

Because of decreased appropriations and manpower, the Army Air Forces withdrew from active participation in the hydroponic program in 1946. The Quartermaster Corps was given authority to approve the establishment of new gardens where the following conditions exist:

a) No soil is available in which vegetables can be grown safely in the normal agricultural manner.
b) The installation is so located that no fresh vegetables can be supplied by shipping in adequate quantity or at reasonable cost.
c) The post camp or station is permanent or is expected to be in existence for a considerable period.
d) There is at least a four-month growing season each year.
e) There is an ample supply of suitable water.

The operation of all overseas hydroponic gardens was assumed by the respective theater commanders. A Technical Manual, *Nutriculture,* was published for the purpose of providing construction and operating data.[13] This Manual indicates that it should be possible to produce tomatoes, for example, at an Army installation in a favorable climate for about one-half the cost of shipping tomatoes to the base by refrigerated maritime shipping over a distance of 1,000 miles. This takes into account a 30 percent loss due to spoilage.

At the present time in the United States,

there is widespread interest in soilless culture in southern Florida, where approximately 20 installations produce vegetables chiefly for the winter market (Fig. 4). In the Northern states the method is used in greenhouses for winter production of tomatoes and cucumbers and also for growing ornamentals, roses, carnations, and chrysanthemums. Shortages of critical materials and chemicals, as well as a serious lack of trained operators, are restraining the spread of soilless culture. Present installations have not produced outstandingly greater yields, and consequently there has been little inducement to change production systems. Recently the development of a method of subirrigating benches containing soil has given promise of achieving many of the same results as soilless culture with less difficulty than in the latter method. This method, in principle, was described by Jones and Doran in the *Florists' Exchange* for May 29, 1943[9] and by George Ball in the *Florists' Review* for May 27, 1943.[1] Kenneth Post, at Cornell University, has extended these results and applied them to entire greenhouse benches.[34] A concrete, or suitably waterproofed wooden, bench is partially filled with an inch or two of gravel and sand. A constant water level is maintained in the sand by means of an automatic float valve attached to the water inlet. The bench is filled with soil kept at any desired moisture content by capillary rise of the water from the sand and gravel in the bottom of the bench. Too high a level of water in the gravel results in saturated soil and the production of anaerobic conditions. Conversely, too low a level results in a loss of capillary rise. It is, however, relatively easy to adjust the water level so that favorable growth conditions obtain. Less attention is required for adjustment of the nutrient level in the soil than is required where soilless culture is used. The method holds much promise, although it has not been tested enough for complete evaluation.

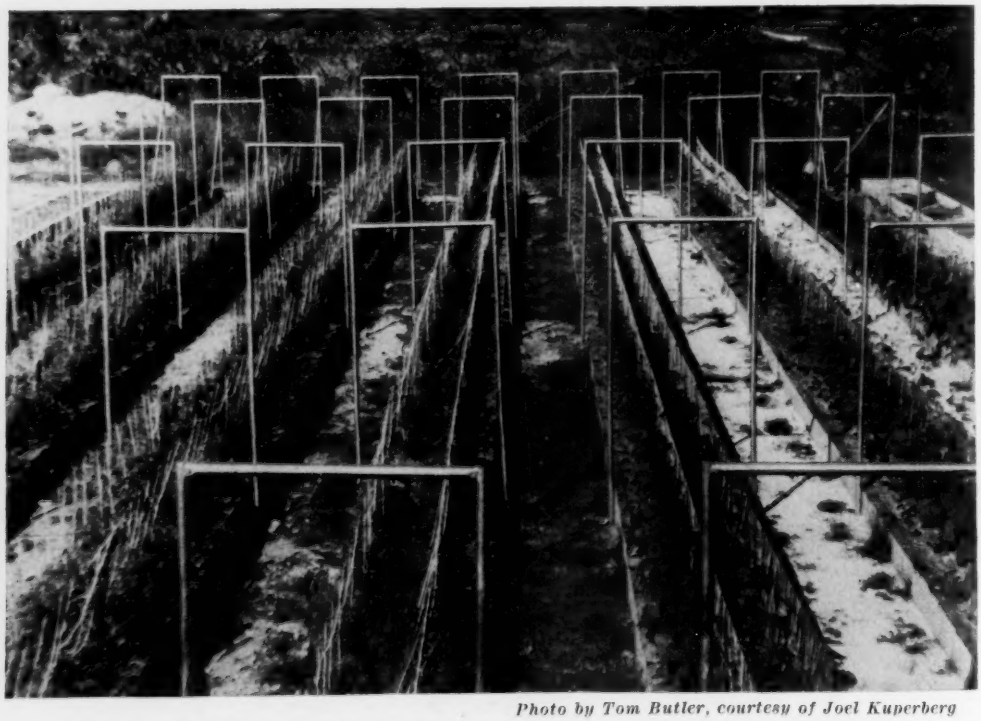


Photo by Tom Butler, courtesy of Joel Kuperberg

FIG. 4. TYPICAL SOILLESS CULTURE BEDS, SOUTH MIAMI, FLORIDA

HERE TOMATOES AND CUCUMBERS ARE BEING GROWN COMMERCIALLY BY THE SOLARIPE HYDROPONICS CORP.

Photo by Bureau of Plant Industry, Soils, and Agricultural Engineering, U.S.D.A.

FIG. 5. CHRYSANTHEMUMS GROWING IN SUBIRRIGATED GRAVEL

LIKE THE LILIES ON THE COVER OF THIS ISSUE, THESE PLANTS ARE BEING STUDIED AT BELTSVILLE, MD.

At the Plant Industry Station, Beltsville, Maryland, soilless culture investigations have been in progress since 1941. The section working with floriculture and ornamental horticulture of the Division of Fruit and Vegetable Crops and Diseases, Bureau of Plant Industry, Soils, and Agricultural Engineering, maintains 20 concrete greenhouse benches comprising 5,400 square feet and divided into 88 sections, each section being provided with a solution tank and pump for subirrigation, so as to give control of experimental treatments. These benches are used in growing plants in phytopathological, genetic, and physiological investigations.[3, 11, 12, 19] The last include studies on nutrient balance and absorption, effect of temperature, light, growing medium, etc. (Fig. 5). It is now generally recognized that rather wide limits of solution composition are capable of producing equally good growth with many plants. Less attention has been given in the past to the choice of the growing medium, other than soil, and its possible role in furnishing nutrients to the crop growing in it.

One of the soil substitutes now in use at Beltsville, expanded vermiculite, has proved superior to soil or sand for certain horticultural purposes.[18] This product is obtained from naturally occurring deposits in Montana and other locations in this country. It is classified as a hydrated magnesium aluminum silicate and is used extensively as an industrial insulating material. The ore is laminated and made up of two minerals, vermiculite and biotite. In the former the scales are bonded together with water molecules and in the latter with potassium. When the ore is heated to about 2,000° F., the water is converted to steam and expands the ore from twelve to fifteen times its original volume. The resulting product is sterile, light in weight, highly absorbent, and retentive of water and air. These physical properties make vermiculite well adapted as a medium for subirrigation. In addition, the available calcium, potassium, and mag-

nesium are sufficient for seedling growth until they are of transplanting size. Vermiculite is also useful as a propagating medium in the cutting bench and as a growing medium in subirrigated nutriculture benches. A valuable property of the material is a water-holding capacity so great that nutrient solutions need to be pumped into the benches only once or twice a week.

Sintered shale, known as Haydite, a commercial product used in making low-density concrete, is another useful growing medium. It is porous, light in weight, and has a higher water-holding capacity than gravel. It, too, contains calcium and potassium that are available to plants growing in it. Haydite has the further advantage of being more durable than vermiculite.

Since phosphorus and iron in the nutrient solution tend to precipitate each other, the maintenance of a low level of the former is desirable in order to avoid iron deficiency. Such maintenance of a low, but adequate, level of phosphorus requires that frequent additions be made to the nutrient solution. Trials have been made at the Plant Industry Station since 1945 to determine whether untreated Florida pebble phosphate rock, as well as defluorinated phosphate rock, used as media in subirrigated nutriculture benches, would provide sufficient phosphorus for satisfactory growth of various floricultural crops. These phosphate-containing materials were obtained from the Coronet Phosphate Company, through K. D. Jacob, Division of Fertilizer and Agricultural Lime of this Bureau. Concrete bench sections 12 feet long, 57 inches wide, and 7 inches deep were filled with these two materials and others with washed pea gravel. The aggregates ranged from 1/16 to 1/2 inch in particle size. A complete nutrient solution, except that it contained no phosphorus, was pumped daily into the beds containing the phosphate media. Similar sections containing gravel received the same solution and in addition 3.8, 7.7, 15.5, or 31 parts of phosphorus (as P) per million of the solution, were added at two-week intervals. The entire solutions were replaced monthly. The phosphorus content of each solution was determined photometrically, using the amino-naphthol-sulfonic acid and ammonium molybdate method, just before new additions of phosphorus were made or the solutions were replaced. These data show that the amount of phosphorus in the solution from the phosphate media was always less than 1 and usually less than 0.5 p.p.m. More phosphorus and considerably more calcium were released from the defluorinated product than from the untreated pebble phosphate rock. The pH of the solution from the former tended to rise above 7.

Growth data show that six varieties of chrysanthemums were able to obtain sufficient phosphorus from the pebble medium to equal the growth of plants in gravel that received 300 liters of solution containing 15.5 p.p.m. of phosphorus at two-week intervals. Growth of the plants in defluorinated rock was inferior to that in the untreated phosphate rock. The same two materials have been used for the growth of snapdragons and Easter lilies with very satisfactory results.

In nutriculture tests nitrogen is the element absorbed by plants in largest quantities and is the one producing the greatest effect on growth. During rapid growth, plants rapidly deplete the nitrogen content of the nutrient solution. The use of natural organic nitrogen materials that would liberate nitrogen over an extended period is not feasible in soilless culture because of the disease hazard.[12] However, the same effect has been accomplished by the use of urea-form fertilizers prepared and made available by the Division of Fertilizer and Agricultural Lime of this Bureau.[4]

Four preparations with urea/formaldehyde mol. ratios of 1.15, 1.20, 1.27, and 1.31 (Table 1) were used as the source of nitrogen for growing nine species of plants in subirrigated greenhouse bench sections containing Haydite. Each section was 8 feet long, 57 inches wide, and 7 inches deep. Two hundred liters of a complete nutrient solution, except for nitrogen, were pumped into each section twice daily. One hundred grams of the urea-form materials were added to the solution tanks on April 2, April 16, May 14,

TABLE 1

PROPERTIES OF UREA-FORM MATERIALS SUPPLIED BY THE DIVISION OF FERTILIZER AND AGRICULTURAL LIME

Sample	U/F Mol. Ratio	Total Nitrogen Percentage	Solubility Index p.p.m.
G–4	1.15	37.06	42
G–2	1.20	37.68	73
G–3	1.27	38.50	105
G–5	1.31	38.50	131

and June 11. Other elements were added to the tanks in amounts sufficient to provide for good growth. For comparison, other sections were provided with the same nutrient solution and 70 p.p.m. of nitrogen from sodium nitrate and ammonium sulfate. Additions were made weekly to this solution until a total of 406 p.p.m. of nitrogen was added between April 8 and July 3. The nitrate nitrogen content of the solutions was determined photometrically by the phenoldisulfonic acid method at weekly intervals until the plants were in bloom and after they were harvested.

The solution analyses show that more residual nitrate nitrogen was present in the solutions containing the higher mol. ratios of urea-form 1.27 and 1.31 than in the solutions with the lower ratios, 1.15 and 1.20. The plant weight data confirm the fact that more nitrogen was available from the higher-ratio urea-form than from the lower. The nitrogen in urea-form 1.15 and 1.20 was not sufficiently available for optimum plant growth. Urea-form 1.27 and 1.31, on the other hand, produced larger plants than did the inorganic nitrogen solution that was partially renewed every week.

After the plants were harvested on July 22, the nutrient solutions were pumped into the beds twice daily until August 26. Although no urea-form was added after June 11, nitrate nitrogen continued to accumulate in the nutrient solutions roughly in proportion to the mol. ratios of the four materials. The use of urea-form, together with some inorganic nitrogen, would seem desirable in soilless culture studies and should result in maximum growth with minimum adjustment of the solution.

In the two hundred and fifty years since Woodward grew his spearmint, much progress has been made in soilless culture. One of his conclusions is still worth repeating: "There is a procedure in every part of nature that is perfectly regular and geometrical, if we can but find it out; and the further our searches carry us, the more shall we have occasion to admire this and the better it will compensate our labour."[22]

REFERENCES

1. BALL, G. J. Subirrigation of Flats. *Flor. Rev.*, 1943, **92**, 16–17.
2. BIEKART, H. M., and CONNORS, C. H. The Greenhouse Culture of Carnations in Sand. *N. J. Agr. Exp. Sta. Bull. 588*, 1935.
3. BRIERLEY, P., and STUART, N. W. Influence of Nitrogen Nutrition on Susceptibility of Onions to Yellow-Dwarf Virus. *Phytopathology*, 1946, **36**, 297–301.
4. CLARK, K. G., YEE, J. Y., and LOVE, K. S. Urea-form—A New Synthetic Nitrogen Fertilizer. Preparation and Properties. 112th Mtg. Am. Chem. Soc., 1947.
5. DAVIDSON, O. W. Large-Scale Soilless Culture for Plant Research. *Soil Sci.*, 1946, **62**, 71–86.
6. ELLIS, C., and SWANEY, M. W. *Soilless Growth of Plants.* (2nd ed., rev. and enlarged by TOM EASTWOOD). New York: Reinhold, 1947.
7. GERICKE, W. F. *The Complete Guide to Soilless Gardening.* New York: Prentice-Hall, 1940.
8. HOAGLAND, D. R., and ARNON, D. I. The Water-Culture Method for Growing Plants Without Soil. *Calif. Agr. Exp. Sta. Cir. 374*, 1938.
9. JONES, L. H., and DORAN, W. L. A Practical Method of Sterilization and Subirrigation of Soil in Flats. *Flor. Exch.*, 1943, **100**, 9, 11.
10. LAURIE, ALEX. The Use of Washed Sand as a Substitute for Soil in Greenhouse Culture. *Proc. Amer. Soc. Hort. Sci.*, 1931, **28**, 427–31.
11. MCCANN, L. P., and STUART, N. W. Nutrient Tests on Stocks in Vermiculite at Beltsville Station. *Flor. Rev.*, 1947, **100**.
12. MCCLELLAN, W. D., and STUART, N. W. The Influence of Nutrition on Fusarium Basal Rot of Narcissus and Fusarium Yellows of Gladiolus. *Am. J. Bot.*, 1947, **34**, 88–93.
13. Nutriculture. *War Dept. Tech. Man.*, 1946, 20–500.
14. POST, K. Automatic Watering. *N. Y. State Flower Growers Bull.*, 1946, **7**, 3–8.

15. ROBBINS, W. R. The Possibilities of Sand Culture for Research and Commercial Work in Horticulture. *Proc. Amer. Soc. Hort. Sci.*, 1928, **25**, 368–70.
16. ROBBINS, W. R. Growing Plants in Sand Culture for Experimental Work. *Soil. Sci.*, 1946, **62**, 3–22.
17. SHIVE, J. W. Sketch of the Development of the Water Culture Method of Growing Plants. *Sci. Mon.*, 1940, **51**, 233–40.
18. STUART, N. W. Expanded Vermiculite Gives Excellent Propagation Results. *Flor. Rev.*, 1946, **98**, 33–34.
19. STUART, N. W., and GRIFFIN, D. M. The Influence of Nitrogen Nutrition on Onion Seed Production in the Greenhouse. *Proc. Amer. Soc. Hort. Sci.*, 1946, **48**, 398–402.
20. War Department Hydroponic Gardens Supply Remote Army Stations with Increasing Amounts of Fresh Vegetables. Press release, U. S. War Dept., 1947.
21. WITHROW, R. B., and BIEBEL, J. P. Nutrient Solution Methods of Greenhouse Crop Production. *Purdue Univ. Agr. Exp. Sta. Cir. 232*, 1938.
22. WOODWARD, J. Thoughts and Experiments on Vegetation. *Philos. Trans. Royal Soc. London*, 1699, **21**, 382–98.

THE WEATHERMAN

The Weather Bureau now has maps recording daily conditions in the Northern Hemisphere for some forty years—the maps, with their meteorological whorls, much resembling large fingerprints—News report.

He has long fathered and excused
The prodigals and profligates—
The searing sun
That turns the fields a parchment brown,
The raiding rains
That steal the precious holidays,
The mayhem winds
That stave in roofs and smash at dykes—
And all the calms of in-between,
The means of fair and moderate.
But now he has a science system.
He fingerprints his sons
And charts their growth.
He's studied their heredity,
The homes from whence they come,
And knows from fingers' whorls
How aberrants are born.
And he can warn
Of sudden treachery in March,
Delinquency in charming April's youth,
Of silent felons in a summer's night
And arson in the fall.

JOSEPH HIRSH

THE RETURN OF BLUEBACK SALMON TO THE COLUMBIA RIVER

FREDERIC F. FISH

Dr. Fish (Sc.D., Johns Hopkins, 1931) received his graduate training as parasitologist at the School of Hygiene and Public Health at Johns Hopkins. He was appointed aquatic biologist in the old Bureau of Fisheries in 1931 and conducted research on the pathology of fishes in the East before being detailed to the Seattle, Washington, laboratory in 1935. As chief, Western Fish-Cultural Investigations, U. S. Fish and Wildlife Service, with headquarters at Oregon State College, he has directed the research program in the application and development of artificial propagation of salmon on the Pacific Coast, particularly at the Service's Grand Coulee fish-cultural stations.

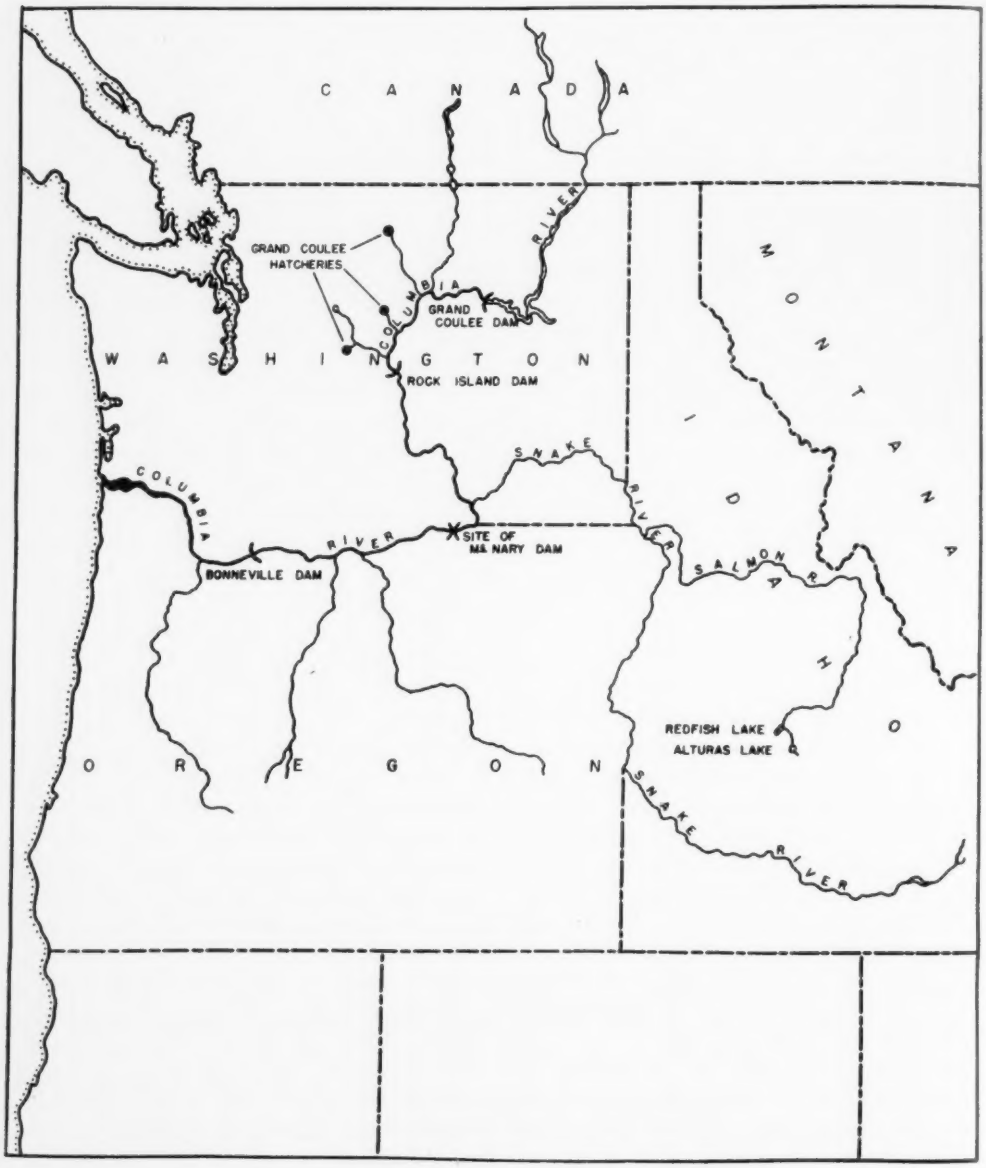
THE year 1941 was a crucial one for the blueback salmon of the Columbia River. During that year, one brood came closer to extinction than was realized by more than a few individuals. The immediate causes were not overfishing, hydroelectric power development, or irrigation—although these factors continued to exert their long-standing effects. The direct causes can be attributed to an "act of God" plus—in large measure—lack of knowledge concerning the basic principles of effective artificial propagation.

With the security and assurance provided by subsequent developments, those concerned with the Columbia River blueback salmon may be interested in a brief recapitulation of events that transpired during the early 1940s. This particular piece of fishery history bears upon the problems of the immediate future on the Columbia River.

The commercially important species of salmonid fishes of the Columbia Basin are the chinook, silver, chum, and blueback salmon, as well as the steelhead trout. Of these, the blueback now contributes but a small bit to the total fishery resources—or approximately 2 percent of the commercial salmonid-fish yield of the river during recent years. In spite of its small part in the fishery resources, however, the blueback salmon offers a valuable "biological indicator" of the general over-all rise and fall of the fish populations, for it alone spawns exclusively in the upper river. For this reason, the counts of fish passing Bonneville Dam, which have been recorded continuously by the War Department Corps of Engineers since May 1938, include all blueback salmon escaping the commercial fishery of the lower river. The annual count at Bonneville Dam, plus the commercial catch of the lower river and minus the commercial catch of the river fishery above Bonneville, yields a reasonably accurate estimate of the total run of this species to the river for the year. A similar evaluation cannot be made for the commercially more important species because of their common characteristic of spawning in considerable—and unknown—numbers in the tributaries entering the Columbia below Bonneville Dam. The same factors—disregarding those of purely local consequence—affect all species of salmon in the same way, although to a varying degree. A factor adverse to the blueback will, in general, prove adverse to the silver or to the chinook as well. Likewise, general measures effective in rehabilitating the blueback runs presumably would prove beneficial if applied to the other species.

It is often assumed that the blueback salmon spawn rather generally throughout the upper Columbia Basin. The evidence is quite conclusive that such is not the case, for this species spawns only in streams tributary to a lake in which the progeny remain during their first year of life. All lakes of the upper Columbia Basin now accessible to migratory fishes lie above the Rock Island Dam—with

the exception of Redfish and Alturas lakes in the Salmon River drainage. No doubt these two relatively small lakes contribute their share to the Columbia River blueback resources, but that contribution must be small in comparison with that from the larger and more numerous lakes of the upper Columbia. Although the construction of Grand Coulee Dam in 1939 blocked access to important lakes formerly frequented by the blueback salmon, still the runs belonging to those lakes continue to pass over the Rock Island Dam en route to the upper Columbia. Fish counts, maintained at the Rock Island Dam since 1933 by the U. S. Fish and Wildlife Service, are believed to



THE COLUMBIA BASIN

SHOWING THE LOCATION OF DAMS, HATCHERIES, AND LAKES MENTIONED IN THE TEXT.

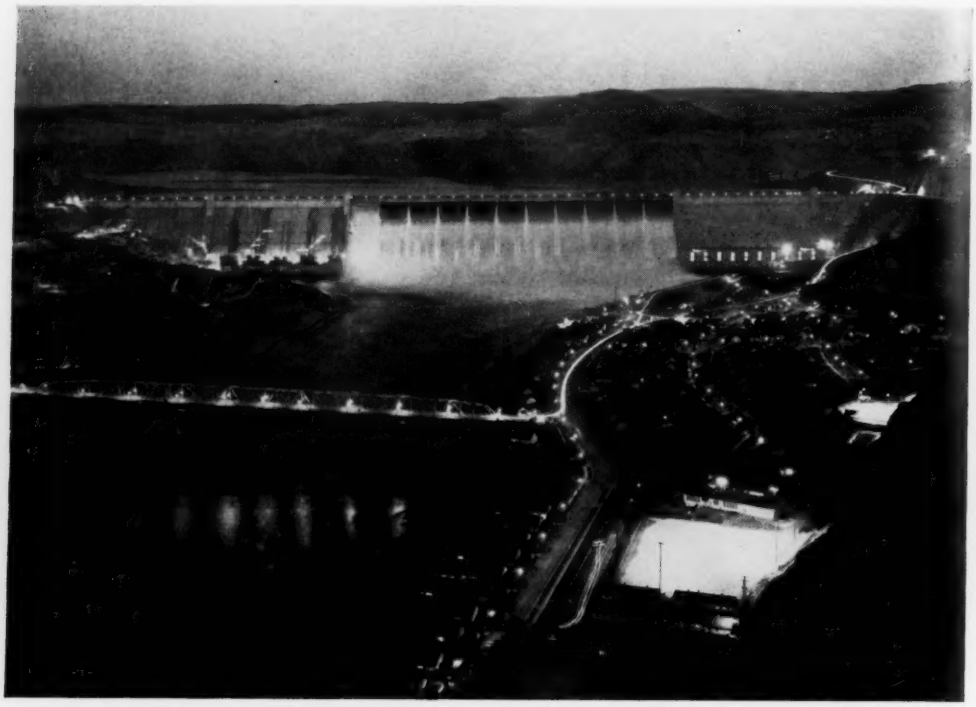
LEAVENWORTH (WASHINGTON) STATION, FISH AND WILDLIFE SERVICE

CENTER FOR BLUEBACK SALMON PROPAGATION IN THE GRAND COULEE FISH-MAINTENANCE PROJECT.

constitute a reasonably accurate index of the number of blueback salmon actually reaching the spawning grounds.

From all outward appearances, there was little to indicate that 1941 was an atypical year for the blueback salmon. The commercial pack of 33,070 cases and the Bonneville count of 65,741 both were well within the realm of normal. Although the commercial fishery above Bonneville took an estimated 65 percent of the fish passing Bonneville (in comparison with a "normal" take of about 40 percent), still the calculated escapement to the spawning grounds was not too far from the ordinary. It was not until it was learned that the run of bluebacks passing Rock Island Dam that year amounted to only 949 fish that definite evidence of an atypical development was at hand.

There still is no clear-cut explanation as to why, of the 25,000 fish estimated to have escaped the commercial fishery in 1941, only 949 appeared at Rock Island. Probably the most acceptable explanation lies in the abnormally warm water temperatures that prevailed that year. Between June 15 and August 31, 1941, the temperature of the Columbia River at Bonneville averaged 68.5° F. in comparison with a normal average temperature approximating 66° F. On July 20, 1941, the Columbia reached an all-time high temperature of 74.5° F.—hot water indeed for the blueback salmon, but a congenial temperature for certain of their microscopic enemies. One of these, the myxobacterium *Chrondrococcus columnaris*, markedly affected by water temperatures, is particularly lethal to blueback salmon. Below 60° F., columnaris disease is of little consequence, but between 60° and 70°, *C. columnaris* invades the inevitable cuts and abrasions on fish, quickly establishing a secondary infection that may prove lethal. Above 70° F., *C. columnaris* becomes a path-



Courtesy of the U. S. Bureau of Reclamation

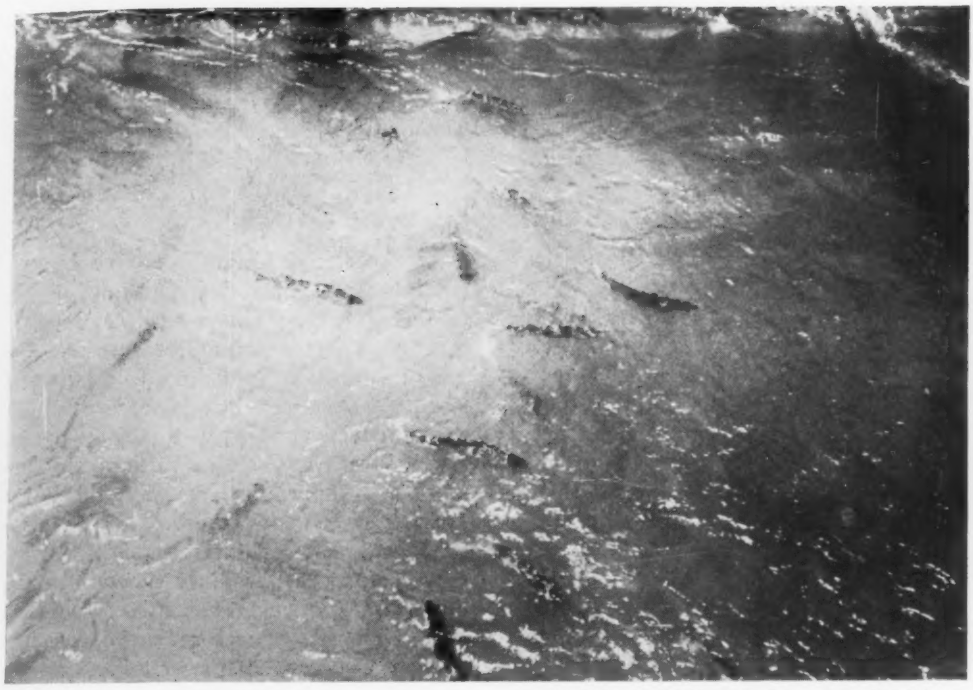
GRAND COULEE DAM

IN 1939 THIS DAM CLOSED THE MIGRATION ROUTE OF THE UPPER-RIVER SALMON.

ogen in its own right and needs no mechanical injuries to open a door through the protecting mucous coating of the skin and gills. In the high sixties, a degree or two difference in temperature spells a great difference in the severity of columnaris disease. It was common talk during the summer of 1941 that blueback salmon were turning into Draino Lake, the Big White Salmon River, Eagle Creek, and other lower Columbia tributaries, in which they did not belong, presumably seeking relief from the abnormally warm water. It is assumed that *C. columnaris* affects the runs to some degree each year, but that it was particularly serious during 1941 because of the higher water temperatures.

The appearance of only 949 bluebacks at Rock Island Dam in 1941 offered definite proof that an abnormal situation had developed. When 851 of the 949 died in the Grand Coulee hatchery holding ponds prior to spawning, it was clear enough that the abnormality had reached cataclysmic proportions.

A digression is in order at this point to explain why the adult bluebacks were in hatchery holding ponds during the summer of 1941. When Grand Coulee Dam blocked the upper Columbia to migratory fishes in 1939, all fish were relocated from their ancestral spawning grounds by trapping them in the fish ladders at Rock Island Dam for distribution by tank truck to hatcheries, or to suitable tributaries entering the Columbia River between Rock Island and Grand Coulee Dams. The unprecedented relocation experiment was predicated upon validity of the "parent-stream theory," by which it was assumed that the progeny of the relocated fish would return to the streams in which they were spawned and reared and not to their ancestral spawning areas. If so, the trucking could be discontinued after one full cycle. The relocation of the upper Columbia salmon runs—known as the Grand



Courtesy of the U. S. Bureau of Reclamation

ADULT BLUEBACK SALMON EN ROUTE TO THEIR SPAWNING GROUNDS

THIS SPECIES AVERAGES ABOUT THIRTEEN INCHES IN LENGTH AND FOUR POUNDS IN WEIGHT.

Coulee Fish-Maintenance Project—was performed by the Fish and Wildlife Service between 1939 and 1944 and proved eminently successful. Because the blueback runs were obviously small at Rock Island during the summer of 1941, all but 22 of the 949 fish were taken to the hatcheries for artificial propagation—supposedly in the interests of greater protection.

The story of the Columbia River bluebacks at the end of 1941 added up to the following facts: the 1945 run would be small at best, for it would be composed of virtually nothing except the minority three-year and five-year age classes; and, short of a miracle on the Fish and Wildlife Service's Grand Coulee Fish-Maintenance Project, the Columbia River blueback was destined to join the ranks of extinct species at a very early date.

Both these prophecies were amply fulfilled in 1945. The commercial pack of blueback salmon that year amounted to a mere 112 cases. The Bonneville count hit bottom with but 9,501 fish of this species counted over the boards.

Small wonder it was, then, that on July 7, 1946, the *Oregon Journal*, a Portland newspaper, featured an editorial under the title "Blueback Swan Song" stating, in part:

> The concrete curtain that fell on the Columbia River salmon runs at Grand Coulee in 1938 has claimed its price in fish life. The principal victim has been the choice blueback salmon. The commercial importance of this fish virtually disappeared in 1945 in the Columbia River. Only 112 cases of this rich and high quality fish were canned in all the canneries from The Dalles to the sea. . . . Biologists knew the fate facing the blueback when the dam began rising from the bottom of the Columbia. Their only hope was transplanting matured blueback, headed above Grand Coulee, into blueback streams below the dam. The U. S. Fish and Wildlife Service in 1939, and for several seasons afterwards, captured upstream blueback migrants at Rock Island Dam below Grand Coulee and transplanted them to the Okanogan and Wenatchee Rivers which have lakes at their headwaters. . . . How successful these transplantings were cannot be determined but the obvious fact is that there has oc-

Courtesy of the U. S. Bureau of Reclamation

EGGS FOR ARTIFICIAL PROPAGATION

SINCE THE PACIFIC SALMON INVARIABLY DIE FOLLOWING SPAWNING, IN HATCHERY OPERATIONS THE SEXUALLY MATURE FEMALE FISH ARE KILLED AND THE EGGS REMOVED BY INCISION OF THE ABDOMINAL CAVITY.

curred a wiping out of the major part of the Columbia's blueback population in the course of a few years. . . . It all adds up to the fact that Oregon and Washington have lost a valuable fishing industry.

That was the low point in blueback history. Two weeks later, on July 23, 1946, the Portland *Oregonian* carried an Astoria dispatch headlined BLUEBACKS IN COMEBACK. This dispatch stated, in part:

The blueback salmon, choicest of all the varieties of fish that frequent the Columbia River, is making a comeback. The annual blueback run suffered a drastic annual decline in volume from 1940 through 1945 until, in the latter year, commercial fishing of blueback was almost nonexistent. . . . In the present season, the blueback count at Bonneville has already reached 51,451 and is expected to exceed 60,000 before the end of the run. This has taken place despite the fact that commercial fishermen, elated over the reappearance of the run, have taken 49,000 pounds so far this season.

Just thirteen months later—on August 23, 1947—the Associated Press carried this dispatch:

The rejuvenated blueback salmon run resulted in a catch of more than a half million pounds for Columbia River fishermen this June and July. The Oregon State Fish Commission reported this and said a joint Oregon-Washington study would be made in an attempt to determine if the blueback is back to stay.

In short, the Columbia River blueback resources, which had dwindled since the turn of the century, really went into a tailspin during the forties and arrived at the threshold of extinction in 1945. Just two years later, the resources bounced back to provide a commercial yield equal to any of the past twelve years and still furnish a spawning escapement approximately twice that of any previous year of record. The obvious question arises: Is this spectacular development of the past summer merely the final burst of a skyrocket, or can the resources be sustained? A critical review of pertinent data may reveal the answer.

The blueback runs of the Columbia River unquestionably have diminished since the heyday of the nineties, when some 2,400,000 pounds constituted an average annual pack for this species. Packs of this magnitude became progressively less frequent following the turn of the century—the last one having been recorded in 1923. Presumably, competing water interests progressively eliminated many of the natural blueback spawning areas during the first two decades of the twentieth century, with the inevitable consequence that the yields diminished. The blueback fishery was more or less stabilized during the later twenties and thirties—only to drop hard in the early forties.

The story of the Columbia bluebacks during the past twelve years—a period that includes the end of the stable period, the drop, and the recovery—is presented by the data in Table 1. These data indicate that the blueback runs were reasonably stable until 1941. They also indicate that the virtual extinction of the blueback runs—bemoaned with good reason by the editor of the *Oregon Journal*—was a reality, and that the low pack of 1945 did not stem merely from the fish

eluding the fishermen's nets. Finally, these data indicate that the recovery of the fishery mentioned in the press during 1946 and 1947 also was a reality, for *both* the take by the commercial fishermen and the escapement of fish to the spawning beds rose sharply to indicate a total run almost double that during the stable period between 1936 and 1941.

TABLE 1

DATA AND ESTIMATES OF COLUMBIA RIVER BLUEBACK RUNS, 1936–47

Year	Estimated Number of Blueback Taken in Commercial Fishery[1]	Effective Escapement to Spawning Grounds (Rock Island Count)	Gross Estimate of Total Run to River
1936	104,400	16,501	120,901
1937	83,800	15,087	98,887
1938	106,157	17,123	123,280
1939	67,157	19,591	87,072
1940	90,480	26,894	117,374
1941	126,242	949	127,191
1942	48,120	15,782	63,902
1943	36,336	17,665	54,001
1944	13,980	4,932	18,912
1945	2,149	7,120	9,269
1946	12,500[2]	46,563	59,063
1947	125,000[2]	79,489	204,489

[1] Poundage of bluebacks landed on Columbia River, as reported by the Washington State Department of Fisheries, divided by 4 to convert to numbers of fish.

[2] Numbers estimated from press releases—official data not yet tabulated.

The evidence is conclusive that only a great increase in the number of bluebacks entering the river during the past summer can account for both phenomena. The high count at Rock Island Dam (approximately one-half the Bonneville count) continues to indicate that the great majority of the 1947 bluebacks were bound for the upper Columbia, for approximately one-half of the fish passing Bonneville normally are caught in the upriver fishery. If these assumptions are tenable, the key to the exceptional 1947 runs should be sought in the history of the parent brood (1943) in the area above Rock Island Dam.

All fish passing Rock Island Dam since 1938 have been involved in the Fish and Wildlife Service's Grand Coulee Fish-Maintenance Project—from which considerable data are available. Pertinent data from this source are listed in Table 2.

In Column 3 of Table 2, it will be noted that of the parent 1943 brood, 13,254 adult fish were estimated to have spawned naturally. This was by no means an exceptional number, for it was exceeded in 1933, 1935, 1936, 1937, 1938, and 1939. It is, in fact, less than the average number of bluebacks spawning naturally during the previous years of record. During the period 1933–38, the bluebacks had full access to their ancestral spawning grounds of the upper Columbia, as Grand Coulee Dam was not yet a barrier. None of the larger runs of previous years—including the 40,737 of 1933—ever produced a return in any way comparable to that by the 1943 run in 1947. It would appear reasonable to assume, therefore, that successful natural spawning of the 1943 brood did not produce the exceptional developments of 1947.

TABLE 2

PERTINENT DATA ON BLUEBACK SALMON—GRAND COULEE FISH-MAINTENANCE PROJECT—U. S. FISH AND WILDLIFE SERVICE

Year	Rock Island Count	Estimated Distribution of Fish		Progeny Released from Hatcheries as Fingerlings
		Natural Spawning	Artificial Propagation	
1933	40,737	40,737	0	.....
1934	2,227	2,227	0	.....
1935	14,013	14,013	0	.....
1936	16,501	16,501	0	.....
1937	15,087	15,087	0	.....
1938	17,123	17,123	0	.....
1939	19,591	19,591	0	.....
1940	26,894	9,770	17,124	1,008,312
1941	949	78	871	12,459
1942	15,782	10,853	4,929	930,111
1943	17,665	13,254	4,144	2,629,767
1944	4,932	4,764	168	483,305
1945	7,120	6,573	547	721,525
1946	46,563	42,563	4,000	1,295,000[1]
1947	79,489	.....	.....	.....

[1] On hand, August 1947.

Courtesy of the U. S. Bureau of Reclamation
FERTILIZED SALMON EGGS
BEING PLACED IN A TROUGH FOR INCUBATION.

Another source of the phenomenal 1947 runs lies in the 4,144 adult bluebacks of the 1943 run that were spawned artificially in the Grand Coulee hatchery operations. Progeny of these fish—2,630,000 in number—were reared and released from the Grand Coulee hatcheries. These fingerlings may well have produced the run that was not approached by 40,737 fish spawning naturally in the entire upper Columbia ten years before.

Following this thesis, a glance at the last column in Table 2 and the question immediately arises: If 2,600,000 fingerlings of the 1943 brood produced such a large returning run in 1947, why did not the 1,008,000 fingerlings of the 1940 brood produce a run approximately one-half that size in 1944? Familiarity with the history of the Grand Coulee hatcheries will effectively answer that question.

When operations were undertaken at the Grand Coulee hatcheries with the 1940 brood, the techniques used in ordinary short-term rearing constituted the sum of available knowledge about salmon culture. The inadequacy of fish-cultural knowledge became glaringly apparent during the first summer of operations. The diets ordinarily fed at salmon hatcheries proved nutritionally deficient upon prolonged feeding, and the fingerlings literally starved in spite of the enormous quantities of food being fed. In July 1941, I found nine different diseases—not including the nutritional deficiency—raging concurrently in the Leavenworth hatchery rearing ponds, with no effective control measures available for any. Under these circumstances, efficient artificial propagation could not be expected—certainly it was not obtained. Of the 6,065,800 blueback eggs collected from the 1940 runs, only 1,008,312 (or but 16.6 percent of the eggs collected) survived to be released as fingerlings. The remaining 83.4 percent of the egg collections were sacrificed upon the altar of fish-cultural ignorance.

An integrated program of laboratory research was instituted under my direction in July 1941, with the sole objective of determining how salmon could be efficiently propagated artificially. More than 100 diets were subjected to controlled tests, and finally one was compounded that has met all requirements to date. Fish-cultural techniques, which in themselves may cause severe losses of stock, were critically evaluated, and new and efficient methods were developed to replace those found wanting.

The problems offered by infectious diseases required developing an entirely new method of treatment. Formerly, hatchery disease treatments consisted in laboriously seining all fish from the rearing ponds and immersing them in a disinfecting bath. Too often, such handling killed almost as many fish as did the disease being treated. A method eventually was developed whereby a disinfectant could be added directly to the pond—thus not only treating the fish without disturbance, but sterilizing the pond at the same time. New disinfectants were required for this method of treatment, as those com-

monly used were found to kill fish before affecting the microorganisms. Dozens of potential disinfectants were tested, both from the standpoint of toxicity to fish life and their ability to kill bacteria. Finally, one was found that eliminated all infectious diseases at the Grand Coulee hatcheries. This disinfectant was not discovered until August 1943, and it was applied for the first time to fingerlings of the 1942 brood. Unfortunately, the armed forces were taking virtually the entire output of this disinfectant at the time, and little could be spared for treating fish. As a consequence, less than one-half of the 930,000 fingerlings of the 1942 brood could be treated as desired. It is believed, however, that the treated fish—stunted as they were by the earlier ravages of disease, but otherwise healthy at the time of liberation—accounted for the upswing in the blueback runs returning in 1946.

By the time the 1943-brood fingerlings came along, the disinfectant was available in ample quantities, and the fish were routinely treated from the time they started to feed until they were finally liberated. Diseases were continuously eliminated long before they could gain sufficient foothold to affect the fish.

The results following elimination of infectious diseases, coupled with feeding a nutritionally adequate diet, were apparent in the exceptional vigor of the fish. As further evidence, 3,476,192 eggs had been collected from the 1943 brood stock, and 2,910,-421 feeding fingerlings were produced. (The 16.3 percent loss on eggs and fry resulted largely from lack of methods for safely transporting recently collected eggs over rough roads—a problem that subsequently has been solved.) Of the 2,910,421 feeding fingerlings produced, 2,629,767 finally were released—a loss of but 10 percent during the fingerling stage. Even the over-all loss of 24.4 percent on the 1943-brood fingerlings constituted a great improvement over the 83.4 percent loss experienced with the 1940 brood. I well remember an impromptu remark by Mr. Joe Kemmerich, dean of the West Coast salmon-culturists and, at the time, district supervisor of the Grand Coulee stations: "I've been in this game for over 30 years and I never saw fish like these before." The reason for Mr. Kemmerich's statement about the 1943-brood fingerlings contains the probable answer not only to the phenomenal reappearance of the Columbia River bluebacks in 1947, but to the future of the Columbia River salmon fisheries as well.

Courtesy of the U. S. Bureau of Reclamation

SALMON FINGERLINGS

AT THE HATCHERY THESE FISH ARE PROTECTED FROM THEIR NATURAL ENEMIES UNTIL THE TIME OF THEIR MIGRATION TO THE OCEAN.

Since early spring of 1943, the Grand Coulee stations have been turning out fingerling fish that are no mill-run hatchery product. All fish are under constant surveillance, with trained resident biologists checking for abnormal developments and immediately tracing any found to their source. The diets are prepared and fed according to exacting standards—even to the point of using a thermometer to ascertain that the food is of proper temperature to "hold its bind" and thus prevent leaching of the essential water-

soluble fractions. All fish are fed a definite proportion of their body weight—depending upon prevailing water temperatures and the size of the fish—to avoid the undesirable consequences of over- or underfeeding. Disease treatments continue to be applied routinely at periodic intervals as prophylactic measures. Their efficacy is well demonstrated in that each summer one pond of fingerling fish has been left untreated as a proving ground for new and untried disinfectants. Invariably, the old story of a disease epidemic starts to unfold, usually within two weeks after treatments are withheld. The laboratory research continues, although now emphasis is being placed upon a reduction in capital investment and operating costs through the development of efficient types of fish-cultural equipment. This information is being acquired against the time when another salmon hatchery will be built.

The accomplishments of the Grand Coulee hatcheries, beginning with the 1943-brood fingerlings, offers one clear-cut explanation for the exceptional blueback runs of 1947. It is not the only explanation by any means, but it appears the most probable one. The factor of coincidence cannot be overlooked, and future developments alone hold the final proof. Should this explanation prove true, artificial propagation—if properly practiced—can, in the future, adequately assume a far heavier responsibility in maintaining the Columbia River salmon resources than previous accomplishments would indicate.

As for the immediate future, if the Grand Coulee hatcheries were primarily responsible for the 1947 blueback run in the Columbia River, another run of comparable magnitude cannot be anticipated until four years after another fingerling release of a size equal to that from the 1943 brood is again made. As shown in the column of fingerling releases in Table 2, blueback runs to the Columbia up to and including 1950 should be considerably smaller than the 1947 run, for there have been no fingerling releases comparable in size to that of the 1943 brood. Lack of fish and, subsequently, lack of funds have precluded egg takes at the Grand Coulee hatcheries numerically approximating that collected from the 1943 runs. Granted both funds and fish, presumably runs comparable to that of 1947 could be maintained indefinitely as long as conditions in the Columbia River remain essentially unchanged.

In closing, one word of caution appears in order. The construction of McNary Dam obviously precludes maintaining the *status quo* of the Columbia Basin. The effect of this structure upon the salmon resources will remain conjectural until the project has been completed. The proposal has been advanced—more or less in the nature of insurance—that a sizable fraction of the salmon runs now passing the McNary Dam site be relocated downstream into areas below most of the proposed main-stem development. In the case of blueback, relocation to the lower river would necessitate virtually complete dependence upon artificial propagation. Overoptimism toward the potentialities of artificial propagation would be dangerous at this time—even should my hypothesis that the Grand Coulee hatcheries were primarily responsible for the 1947 blueback runs ultimately be proved correct. Even the proved fact that artificial propagation at the Grand Coulee hatcheries did maintain a commercially exploited blueback run would not offer positive proof that the feat could be repeated in the lower river. The accomplishments attributed to the Grand Coulee hatcheries—as well as actual experimental relocations of upper-river bluebacks to a lower-river hatchery, which are producing comparable returns this year—must be accepted as potentially promising experiments at best. Certainly, the 1947 blueback runs should not be interpreted as proof that both bluebacks and dams can exist in the Columbia Basin.

ORIGIN OF THE MIMA MOUNDS*

TROY L. PÉWÉ

After taking his Master's degree in geology at the University of Iowa in 1942, Mr. Péwé became an instructor in that science at Augustana College. He remained there until 1946, when he joined the U.S. Geological Survey Permafrost Division, spending both summers since that time in Alaska: 1946 in the Yukon River Valley and 1947 in the Fairbanks area. During the winter Mr. Péwé is at Stanford University, assembling the facts gathered in the summer.

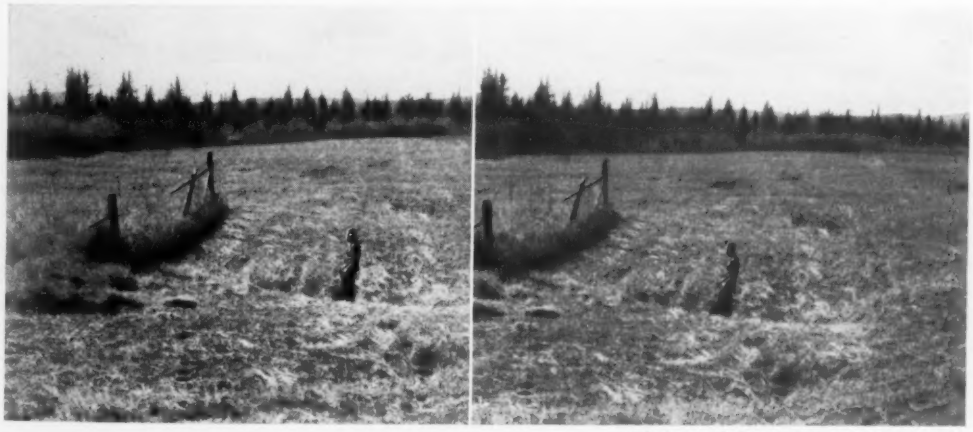
IN A recent paper in THE SCIENTIFIC MONTHLY (1947) and an earlier one in the *Journal of Geology* (1942), Dr. V. B. Scheffer discusses the origin of the large earth mounds on the prairies near the south tip of Puget Sound, Washington. He attributes these mounds to the work of gophers. This is, he states, only one of the many theories suggested for the origin of the mounds.

I have never seen the Mima Mounds but, after comparing descriptions and photographs of these mounds with mounds of a similar nature in the Fairbanks area, Alaska, I am of the opinion that the Mima Mounds may be periglacial phenomena. That these mounds may represent periglacial activity was earlier recognized by H. M. Eakin (1932), a geologist familiar with subarctic phenomena.

The mounds in the Fairbanks area were studied by me during the summer of 1947 in connection with the investigation of the U. S. Geological Survey on the distribution, characteristics, and genesis of permanently frozen ground (the present permafrost program). These mounds will be discussed in a forthcoming paper entitled "The Relation of Permafrost to Agriculture in the Fairbanks Area, Alaska." The Alaska mounds are in silts and fine sands. They vary in diameter from 10 to 30 feet and are 1 to 8 feet in height. These mounds are best developed in areas cleared for agriculture on the low slopes of the hills or on the flat-lying land between the hills and the Chena River floodplain. No mounds were noted on the floodplain.

Large masses of clear ice are very common

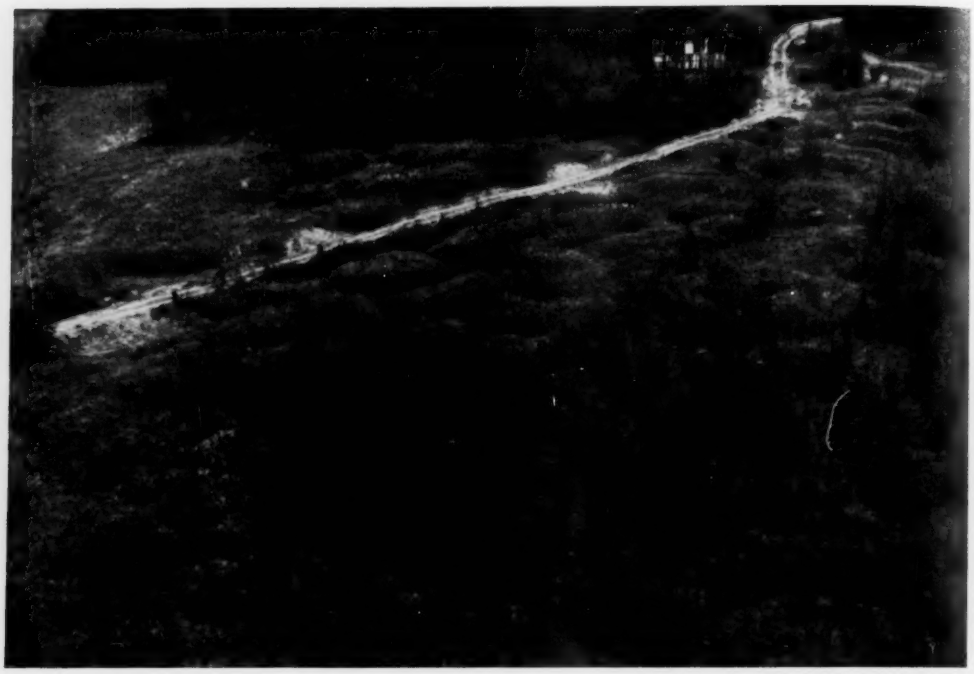
* Published by permission of the director, U. S. Geological Survey. The author wishes to extend his thanks to Mr. R. F. Black and Mr. A. I. Levorsen for calling his attention to the article on the Mima Mounds by Dr. Scheffer; and to Mr. S. W. Muller and Mr. E. Blackwelder, who kindly reviewed the manuscript. Mr. Blackwelder also discussed with the author the mounds of similar nature that occur in California.



Photograph by T. Péwé, August 1947

FIG. 1. STEREOPAIR OF DEPRESSIONS FORMED BY MELTING ICE

IN THIS FIELD, ONE-HALF MILE NORTH OF THE U. S. DEPARTMENT OF AGRICULTURE EXPERIMENT STATION NEAR FAIRBANKS, ALASKA, DISCONNECTED DEPRESSIONS WERE FORMED WHEN UNDERLYING ICE MASSES MELTED.



Photograph by T. Péwé, August 1947

FIG. 2. MOUNDS NEAR THE UNIVERSITY OF ALASKA, FAIRBANKS

Photograph by T. Péwé, July 1947

FIG. 3. CLOSE-UP OF A MOUND NEAR FAIRBANKS

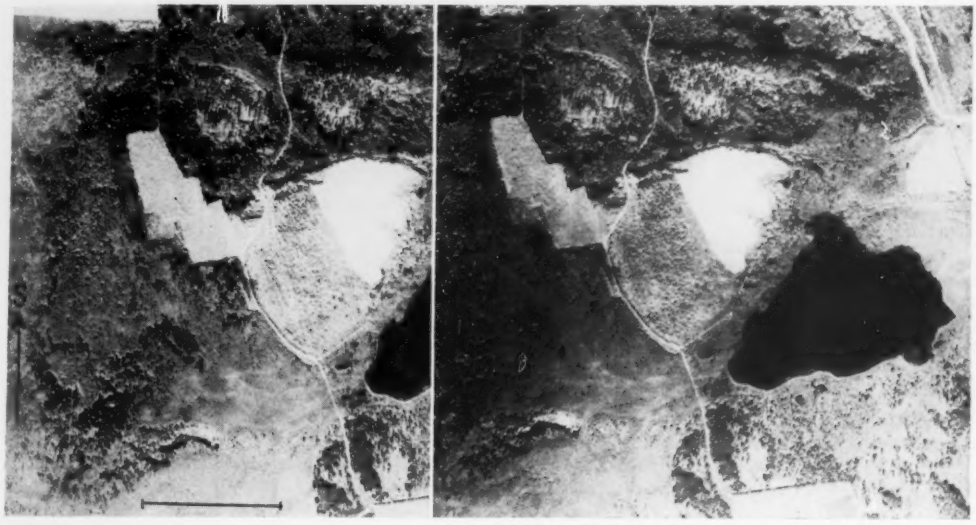
in permanently frozen ground in various regions of the world. Some ice masses occur in polygonal nets, as can be observed today in placer gold-mining operations in the Fairbanks area. Such ice masses also have been encountered by drilling. This common phenomenon has been reported (Leffingwell, 1919, 205; Taber, 1943, 1510; and Black, oral communication, August 23, 1947) from other parts of Alaska.

I believe the Alaska mounds are the result of the melting of a network of ice wedges in the ground. When the ice begins to melt, the overlying ground sinks down. Disconnected depressions in some places appear first (Fig. 1), and, if the ice is in a polygonal, or network, pattern, the ground in the center of the ice network is soon left standing in relief. Drilling into the low areas between mounds has revealed the presence of clear ice. The development of the mounds in the Fairbanks area, which has a mean annual temperature of about 26° F., seems to be dependent upon stripping of the protective vegetative cover.

Figure 2 is a low oblique aerial view of the mounds developed near the University of Alaska, three miles west of Fairbanks. The forested area in the foreground and to the right consists of trees eight to ten years old which have grown on the mounds. The diameters of the mounds are from 10 to 30 feet.

Figure 3 is a close-up of the mounds in Figure 2. The relief of these mounds is about 6 feet. Figure 4 is a stereopair of vertical aerial photographs of the same mounds as those in Figures 2 and 3. W. A. Rockie (1942) studied this field in 1938 and assumed the mounds were caused by melting of "ground ice."

In 1940 R. C. Newcomb presented a theory for the Mima Mounds which assumed the formation of ice wedges by water entering and freezing in cracks formed when the ground contracted in cold weather. The expansion of the freezing water causes bulging in the center of the polygon. He states that when the ice melts out, the interice blocks slump down into mounds. The fact that ice wedges do form in cracks in a polygonal network has been reported from the arctic coastal plains of Alaska by Leffingwell (1919, 205) and Black (oral communication, August 23, 1947). The mounds in the Fairbanks area, however, appear to develop from



Photograph by U. S. Army Air Forces, 1945

FIG. 4. STEREOPAIR OF AERIAL PHOTOGRAPHS OF MOUNDS NEAR FAIRBANKS

THE MOUNDS SHOWN IN FIGURES 2 AND 3 ARE IN THE CENTRAL FIELD OF THIS PICTURE. MOUNDS NOT SO WELL DEVELOPED OCCUR IN THE FIELD TO THE LEFT. THE BLACK BAR ON THE LEFT REPRESENTS 1,000 FEET.

melting of the surrounding ice masses and not from pushing of the earth into a mound by expansion of the ice.

Mr. Newcomb has kindly allowed me to examine his unpublished manuscript entitled "Refutation of the 'Gopher Origin' for the Mima Mounds, Thurston County Region, Washington." In this thorough work it is revealed that not all the mounds are smooth and round; some are polygonal and of various sizes and stages of development. The Alaska mounds are very similar in this respect. One feature brought out by Mr. Newcomb's paper is the existence of "prong depressions." A photograph of these Y-shaped depressions compares exactly with the polygonal trenches common in areas which contain ice wedges throughout Alaska.

Factors that seem to favor the periglacial origin of the Mima Mounds are:

1. The mounds in Washington compare favorably in appearance and development with those of the Fairbanks area, Alaska. The mounds of the Mima Prairie, which are pictured on page 285 of Dr. Scheffer's article (1947), appear very similar to those in an abandoned field on the Farmer's Loop road three miles north of Fairbanks.
2. Features that Dr. Scheffer calls "mound roots" and that appear to be armlike structures of black silt extending into the gravel, may be small fossil ice wedges. Such periglacial phenomena have been described previously (Edelman and Tavernier, 1940, 140).
3. The temperature that existed in the periglacial zone during the glacial period was probably favorable for the development of permafrost.

REFERENCES

DALQUEST, W. W., and SCHEFFER, V. B. (1942) The Origin of the Mima Mounds of Western Washington. *J. Geol.*, **50**, 68–84.

EAKIN, H. M. (1932) Periglacial Phenomena in the Puget Sound Region. *Science*, **75**, 563.

EDELMAN, C. H., and TAVERNIER, P. (1940) Periglaciale Verschijnselen, meer in het bijzonder in de Antwerpsche Kempen. *Natuurw. Tijdschr.*, **22**, (3–7), 139–53.

LEFFINGWELL, E. DE K. (1919) The Canning River Region, Northern Alaska. *U. S. Geol. Survey, Prof. Paper 109*. 251 pp.

NEWCOMB, R. C. (1940) Hypothesis for the Periglacial "Fissure Polygon" Origin of the Tenino Mounds, Thurston County, Washington. *Geol. News-Letter of Geol. Soc. of Oregon County*, 6, 182.

NEWCOMB, R. C. Refutation of the "Gopher Origin" for the Mima Mounds, Thurston County Region, Washington. (Unpub. ms.)

ROCKIE, W. A. (1942) Pitting on Alaskan Farm Lands: A New Erosion Problem. *Geog. Rev.*, **32**, 128–34.

SCHEFFER, V. B. (1947) The Mystery of the Mima Mounds. *Sci. Mon.*, **65**, 283–94.

TABER, S. (1943) Perennially Frozen Ground in Alaska; its Origin and History. *Bull. Geol. Soc. Amer.*, **54**, 1433–1548.

REMARKS ON THE MIMA MOUNDS

The article by V. B. Scheffer on the origin of the Mima Mounds (October 1947 SM) has brought a response from readers even greater than that which followed our publication of C. Wythe Cooke's article on the origin of the Carolina bays (April 1945 SM). In present issue, the preceding and following articles, and letters on the subject in Comments and Criticisms, conclude the discussion in the SM of the origin of natural mounds. Of course the subject may be reopened later if it seems desirable to do so. In the meantime, interested readers should communicate with Dr. W. Armstrong Price, consulting geologist, 907 Medical-Professional Building, Corpus Christi, Texas. Dr. Price is critically reviewing the Mima Mound problem, on which he expects to publish elsewhere.—Ed.

THE SAND MOUNDS OF LOUISIANA AND TEXAS

FREDERICK C. KOONS

The article by Victor B. Scheffer, "The Mystery of the Mima Mounds," in the October SM elicited considerable discussion on the origin of these pimples of the earth's surface in the Pacific Coast states. We have already published in Comments and Criticisms some of the communications supporting or opposing Dr. Scheffer's conclusion that the mounds are not of geological origin but were formed by the activities of pocket gophers. The most remarkable communication relative to Dr. Scheffer's article has come from Mr. Frederick C. Koons, a retired petrolcum geologist, who, at the age of sixty-three in 1926, took a Master's degree in the Department of Geology and Paleontology of the University of Chicago, presenting a thesis entitled "Origin of the Sand Mounds of the Pimpled Plains of Louisiana and Texas." Mr. Koons, writing from his home in Wharton, Texas, submitted to the editor a copy of his "ancient thesis" and gave us the privilege of using it as we wish. Regarding his thesis Mr. Koons wrote in part as follows: " . . . I thought I had proved that the mounds were made by the pocket gopher. But if Dr. Scheffer meets with as much opposition as I did, he may appreciate any support. In this old thesis he will find confirmation on every point; and I have the advantage of having seen it done." As Mr. Koons' observations and conclusions were entirely independent of those of Dr. Scheffer, having been made much earlier and in a different region of the United States, we thought a part of his thesis, published below, would be of interest to our readers.

THE small mounds that dot portions of the coastal plains of Louisiana and Texas, aptly called "the pimpled plains," have aroused speculation on their origin. Most of the observations so far reported have been superficial, and much of the evidence is merely theoretical or hearsay. When I first saw the mounds on a trip to Texas in 1903, I was told that they were caused by gas blowouts. Later my prolonged residence in Texas afforded opportunity for careful and lengthy study. It is my purpose to review briefly the literature on the subject, to state the results of my investigations on the composition of the mounds and their relation to the underlying strata, and to present my conclusions based on observations covering fifteen years.

The mounds under discussion extend from southwestern Louisiana along the coastal plain southward and westward toward Mexico. I have not observed them south of the latitude of Port Lavaca, Texas. The width of the belt of their occurrence is less than 100 miles and was about 60 miles wide where I made my study. They occur invariably on level plains having a surface soil of clay more or less mixed with sand, little or no drainage, and in regions of abundant periodical rainfall.

The surface soil of the type plain where my studies were made is about 18 inches in depth, underlaid in places by lenses of quicksand from 1 inch to 4 inches in thickness. Then comes 15 feet of clay so impervious to water that after a prolonged wet season of as much as three months' duration the clay at a depth of 3 or 4 feet will be apparently dry and present the same appearance to eye and touch that it does after an extended dry season lasting for months. This clay bed is underlaid by a sand stratum of 12 feet and that by another clay stratum of 4 feet. Under the latter is a stratum of water-bearing gravel and sand. The sand between the clay strata is dry at all times, regardless of the surface conditions. Moreover, the amount of water in the water-bearing stratum is in no way affected or controlled by local conditions of precipitation. There is no connection between the underground water and the surface.

The mounds themselves are circular, and their height varies as their diameters, but their relief is not over 24 inches. In composition they are identical with the adjacent soil, which is a clay loam with a varying percentage of sand; but often the percentage of sand is slightly greater than that of the outside area. There is no rock of any kind in the soil nor in the underlying strata until the bottom of the second clay stratum is reached. However, where there is an underlying sand lens there may be found at the bottom of the sand a few pebbles of water-worn gravel, and in some localities there is a small percentage of ironstone nodules, or "buckshot."

Generally, for each mound there is a corresponding depression at one side, and sometimes, but not often, on two sides. These depressions are oriented in no particular way, are oblong, and their width and length vary as the diameter of the mound.

Some of the mounds are pitted at or near the center, usually by one, and rarely by as many as three, small pits.

The mounds show no regularity of distribution and exhibit no trend. There is no evidence of stratification of any sort. In diameter they range from 4 to about 30 feet, but a few are larger.

[*At this point Mr. Koons discussed and rejected eight hypotheses that were suggested in previous literature to account for the origin of the mounds. They were: (1) Differential settling of sediments, (2) segregation of mineral matter, or concretion on a large scale, (3) vertical seepage of water under hydrostatic pressure, (4) gas blowouts, (5) wind drifts, (6) anthills, (7) uprooted trees, (8) man-made. We are omitting his arguments on these hypotheses and other references that he made to the literature because we are primarily interested in his own observations and conclusions.*—Ed.]

As a result of my own observations and investigations on the mounds I offer the following solution to the problem of their origin: The mounds were made by the pocket gopher, *Geomys bursarius,* to enable the builder to keep out of the water. Where there is surface or underdrainage the mounds are not made because they are not needed.

Since the pocket gopher is found on the Great Plains from the south side of the Saskatchewan to the Gulf of Mexico, it may be objected that the gopher does not build mounds on other areas that are sometimes flooded. That is true; but it is also true that both surface and underdrainage are vastly superior to that of the pimpled plains. The surface gradient of the latter is from 3 to 6 feet per mile, which to the eye is a flat surface. The soil, as before mentioned, is thin. The mean annual rainfall at Houston, Texas, is about 50 inches, about twice that of the Great Plains, and is not evenly distributed throughout the year. When the weather is wet it is apt to be very wet for a long period, and of course the dry periods may also be quite long. The underlying clay subsoil being impervious to water, as before explained, the thin stratum of topsoil soon becomes saturated and then flooded. So there is a considerable difference in this respect between the Great Plains east of the Rocky Mountains and the pimpled plains. One familiar with the Gulf coastal plain may urge the objection that not all of it, even in the pimpled plains area of Texas, is of the character described. While that is a fact, it is also true that unless it is of the type character there will be no pimples. For example, there are localities where the type soil borders on an area of heavy, "black-waxy" land, Beaumont clay, which is from 6 to 10 feet or more in depth. The line between the two is often rather sharply defined. There will be mounds on the one and not on the other. Why? The deep soil has a certain amount of underdrainage and, being deeper, much more water is required to saturate and flood it. Furthermore, few gophers will be found there. The gopher's favorite food does not grow very well on black land. Being like putty when wet and very hard when dry, it is difficult to work.

I had in mind, in mentioning the foregoing type locality bordering on black land, the southern part of Colorado County, Texas, southwest of the village of Garwood. Going west from Garwood, we traverse about a mile of black land, very sticky and very deep. It is moundless. After crossing the Mustang Creek we are suddenly out of the black land and on the pimpled plain, which is more or less sprinkled with the typical mounds. A journey of about 14 miles southwest brings

us to Sandy Creek, which flows through a timber belt about 2 miles wide at that point. We are still in the type locality as to soil, except that in places the creek has built up levees. Gophers are abundant on these higher lands as well as on the plain, but there are no mounds.

The manner of constructing a mound is this: the gopher opens his burrow to the surface and piles up a mound of loose earth 2 to 3 feet in diameter and often as much as 18 inches high. He does not use this mound as a residence unless the water forces him to do so. As the plains are usually pastures and there are many cattle on them, the cattle paw and horn down the newly made mounds and scatter the fresh earth. The gophers rebuild it as occasion demands, and it is as often torn down. If the cattle do not demolish it, the weather eventually will; but I have never known the cattle to fail. Before the advent of the cattle there were buffalo, which served equally well.

The material that was piled up was not taken from immediately under the mound, but was carried from a distance through a runway excavated to one side. Usually but one runway was made in the early history of the mound. This was extended, and the excavated material pushed up into place on the dump until the carry became too long; then a branch was made from the first run and earth carried from that until the distance again became too great, whereupon another branch was started; and so on. In that way the depression, which was caused by the eventual settling of the excavated area, came to be on one side of the mound and not all around it. It was simply a borrow pit from which material was taken for the fill: i.e., the mound. In that way the mound came to be made round and the depression oblong. The gopher in his tunneling sometimes went well down to the clay stratum, and if there happened to be a sand lens there he used it, for it was easy digging. In that way it came about that he sometimes put a trifle more sand in his structure than one finds in the surrounding soil. Often he made his mound near some small, shallow lagoon or natural depression. The bulbs of certain lilies were to be had there, and they were harvested when the water evaporated, as it was sure to do in summer. Around such places also grow sedges, *Cyperus esculentus,* which furnish desirable tubers, if we may judge by the amount harvested and stored.

I have now accounted for the mounds and the depressions, but what about the small pit or pits often found near the center? They are secondary, and the gopher had nothing to do with them. We must remember that the gopher uses the mound as an island of refuge and does not generally live there. He prefers to locate his living quarters and storehouse elsewhere, ordinarily. After he has first built up his small mound, and each time thereafter when he works on it, he plugs the opening to the surface when work stops. And he plugs it so skillfully that three minutes after he has finished one may cut a section through it with a spade and find it very hard to determine which part had been hole and which undisturbed soil. But he has neighbors, and when after some years of labor a fair-sized mound has been built up, it oftens happens that some skunk, civet cat, or mink decides that the mound is a nice, high site for a residence and makes a burrow. The newcomer may, and often does, strike the gopher's tunnel, which is enlarged to meet the needs of the invader. But the new burrow, unlike the gopher's, is kept open, since the occupant goes out and in nightly. It is this opening, enlarged by dogs or other animals digging at the entrance or by cattle stepping on the earth just over it and caving it in, that causes the small pits.

To prove the gopher hypothesis, I noted the initiation of mounds and made observations on their progress for some years. Two were noted about three miles apart on trails that I frequently traveled, and their locations marked for identification. They were observed shortly after the initial mounds were thrown up and were kept under observation some years. After five years both had attained fair size and would readily have been classed by the casual observer as "sand mounds." One of them was abandoned when it was included in a rice field and partly plowed down and later flooded by irrigation.

I have never observed a new mound in an old rice field, no matter how long it may have been abandoned for rice culture, provided the check levees had not been plowed down. The gophers appropriated the levees and, not needing mounds, did not build any.

If this solution of the origin of the mounds in question be the true one, then a geological problem has been solved only to raise a biological one. Dare we charge an animal with such a radical change of life habits to meet special environmental needs? Does that noted hydraulic engineer, the beaver, neglect to build a dam where there is plenty of water? How did he become a dam builder in the first place? May not another rodent become an engineer?

I have been over a good deal of the Great Plains region from the Dakotas to the Gulf; the pocket gopher is found more or less in the entire territory, but nowhere except on the pimpled plains have I noted any such work as I have herein attributed to it.

In well-drained regions where gophers are present, they are evidenced by many small earth heaps, which are waste dumps for material excavated in making runways, but these are not enlarged and are merely by-products in the construction of tunnels; whereas on the pimpled plains it would seem that the mound is more than that and that tunneling is sometimes carried on for the purpose of borrowing material from one place for use in another.

Obviously, we must call in expert evidence in the case and, since we have chased our geological constructor into a biological hole, we must consult the biologist.

The biologist says yes in answer to the foregoing questions and presents some evidence in support. The ground squirrel of the Columbia plateau occupies a region of abundant food, but water fails in midsummer. So he simply digs deep, shuts himself up, and goes to sleep until the following spring, according to Shaw. This habit is a local one. Allee, of the University of Chicago, cites the case of the blue heron, which in the forest regions of the East nests in tall trees, but in the treeless wastes of the Great Basin builds on the ground a structure of reeds and mud 4 or 5 feet high in order to place the nest above the water—an entire change of habit. Osgood, of the Field Museum [now the Chicago Natural History Museum], answered the questions in the affirmative and cited the case of the fire ant. On the flood plain of the Amazon thousands of these ants assemble into a compact ball that floats until the flood subsides. The outer individuals drown, but the queen in the center and the inner ones survive. Thus many animals adapt themselves to unusual environments.

My observations may be summarized as follows:

Mounds of the type under discussion are found only on flat, undrained regions that are subject to periodic floods of considerable duration.

Dissection of more than one hundred failed to show any structure whatever, any variation of composition (which is that of the surrounding soil and the latter in turn is formed by disintegration and decomposition of the clay), any disturbance of the fine-textured, very compact underlying 15 feet of clay, or any disturbance of either clay or the 12 feet of dry sand below the clay in three instances where pits 8 feet in diameter were located on mounds and excavated through both clay and sand to the water level in the underlying gravel.

The observation of the habits of the pocket gopher led to the marking of certain initial mounds, keeping check on their manner and rate of growth, and the certainty, in my opinion, of the method of their construction.

THE MEASUREMENT OF MENTAL SYSTEMS

(CAN INTELLIGENCE BE MEASURED?)

W. ALLISON DAVIS and ROBERT J. HAVIGHURST

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THE crucial problem raised by the attempt to compare scientifically the capacity of any two individuals to learn is that of finding situations with which the two individuals have had equal experience. To state this issue more exactly, two major systems of behavior are involved in problem-solving. They are (*a*) the individual's genetic equipment for problem solving; and (*b*) the individual's particular cultural experience, training, and motivation, which have developed certain areas of his mental behavior and certain skills more than others. In a test of general hereditary capacity, the second factor must be equalized for all those tested.

Consider two children with equal hereditary mental factors. The child who obtains more practice in working on mental problems of a certain type will prove superior in that particular area of mental functioning. If one of these equally endowed children is reared in a family of high socioeconomic status, and the other in a slum family, we should expect that the first child will prove superior on academic types of problems, such as nearly all those in "intelligence" tests. This actually proves to be the case, as Newman, Freeman, and Holzinger have shown with identical twins, separated early and reared in different socioeconomic strata.

But if one considers any two children, not genetically identical—and this is the chief task of mental tests—the fact that one child proves superior within a certain narrow range of academic problems does not imply that he is superior likewise in solving more realistic, lifelike problems. Mental processes are highly varied; so are the types of specific mental problems presented by our society. Thus problem-solving activities in man exist as a configuration of systems of activities. In one child, systems A and B may exist at a high level, but systems C and D may exist at a low level, as a result both of genetic factors and of training. A second child may have this pattern of strong and weak activities exactly reversed.

Any scientific effort to compare the mental status of individuals throughout the whole cultural range of the population of the United States, therefore, must satisfy two conditions. Unfortunately these requirements have not been met by the makers of intelligence tests or tests of "mental ability."

The two requirements for such a test may be stated thus:

Since, in life, human beings engage in an incredible variety of mental activities, the testmaker must discover those systems of acts that are most representative of all mental behaviors. In practical terms of testmaking,

this requirement means that those types of problems that are put into tests must represent the wide range of mental systems exhibited by normal human beings (and not merely a sampling of their academic or linguistic activities).

In each mental-system area, the testmaker must select problems common to the culture and practice of all socioeconomic groups in the population to be tested. In addition, the testmaker must learn how to express these problems in symbols common to all the socioeconomic groups to be tested. He must likewise find problems that motivate equally all the groups to be tested.

Although Alfred Binet, who founded modern tests of intelligence, was keenly aware of the danger that his test problems were too scholastic and too closely related to home training, he did not live to face the extremely complex task of creating new tests that would be less biased in these respects. During the past twenty-five years, therefore, many research psychologists have criticized all such intelligence tests as including a strong cultural handicap for pupils of the lower socioeconomic groups.

There has been little serious consideration given, however, to the first criterion mentioned above. In the thirty-five years since Binet's last work, virtually no new types of problems have been included in either the individual or group intelligence tests. The few recent additions have merely extended the old, abstract types of problems, which are dear to the heart of academicians, but seldom or never met by the individual as basic, real-life problems.

We regard mental behavior as the interaction of many systems of mental acts. The Spearman theory considers intelligence as composed of one general (or *G*) "ability" and several specific "abilities." We raise the question whether the testee will have a fair chance, however, to show how much of *G* he possesses unless he has had equal access, with all other testees, to the situations and symbols by which he is tested, and unless he is equally as much motivated as all other testees.

Thurstone's multifactor theory of intelligence supposes that there is a rather small number of independent primary abilities. The necessity for culturally common situations, symbols, and motivation would apply to Thurstone's tests of Primary Mental Abilities also.

Our chief criterion for a measure of general mental behavior is that the problems must represent a wide range of mental systems and mental problems. We do not believe that the present tests meet this criterion. Thurstone isolated his primary abilities by analysis of fifty-six "current psychological tests," constructed by many persons, but all limited, we believe, to a few systems of mental behavior, and formulated in academic abstract problems. Thurstone quite frankly makes no claim that his tests cover a wide range of "mental factors" or problems. F. L. Goodenough has made the same point: "Thurstone's primary abilities are not presumed to cover the complete range of human talent—they involve only the abstract abilities needed for success in the conventional types of intelligence tests and in the academic pursuits of the classroom."

Very recently, Thurstone himself has stated that his "primary mental factors" may vary in their definition. Some may "be defined in endocrinological effects," others in effects of the central or autonomic nervous systems; "still others may be defined in terms of experience and schooling."

Authorities like Ralph W. Tyler, former director of Examinations Staff, U. S. Armed Forces Institute, and Otto Klineberg, of Columbia University, have long emphasized the defects in the present tests of general intelligence. Used widely as a basis for segregating, and discriminating educationally against the lower socioeconomic groups, the tests have levied an irreparable toll upon a whole generation of children from these groups. Tyler has attributed the inadequacies of both the tests and public education to the same blind spot: an overacademic view of human learning. One of the foremost authorities on test construction, Tyler has said:

> The public schools, as well as the standard intelligence tests, fail to tap many vital aspects of intelligence. Both the tests and the schools are caught in a circular kind of educational philosophy.

They assume that only certain kinds of problem-solving activities are diagnostic of "intelligence." Then the schools, supported by the test results, conclude that only those pupils who rank high on this limited, highly specialized range of activities, are "intelligent." This is a narrow, ritualistic concept of mental behavior which causes our communities and our industries a tremendous loss, owing to the failure of the schools to uncover and to train many other kinds of mental activities in all our children. The true learning-potential of the millions of children in our lowest socio-economic groups is not yet known. The efforts of the schools to develop this potential are weak and inept.

The sociologist and social anthropologist have been convinced, through studies of a great many human societies, that cultural learning runs through nearly all the "mental" behavior of human beings. Social anthropologists therefore strongly doubt that cultural behavior can be eliminated from any intelligence-test response.

We hope, however, that cultural bias in the tests, favoring any socioeconomic group, can be eliminated. This position requires the construction both of test problems and of total testing situations that so control all the major cultural elements in these tests that no cultural advantage is offered to any socioeconomic group in the United States.

Cultural systems in the United States: Fortunately, sociologists and social anthropologists now have developed a typology of the cultural systems within the United States. We know that Americans exhibit three major types of cultural behavior. These are:

a) The common American cultural traits and behaviors.
b) The various cultural behaviors of the different socioeconomic (social-class) groups.
c) The cultural patterns of the different "ethnic" or nationality groups.

The culture of the United States, in which the test problems inevitably must be expressed, is therefore composed of (*a*) common problems and behaviors and (*b*) limited, "subcultural" traits or problems. Here, then, in this discrimination between common cultural problems and more limited subculture-group problems, lies the way to improve our tests of general problem-solving activities. We must try to control or equalize the cultural factors in test problems if we hope to use these problems to measure comparative ability (that is, mental activity as developed in similar learning environments). One way to attack this problem would be to try to avoid all types of problems in which one socioeconomic group (and this means, in present test practice, the middle-class group) has had more training and experience than some other group. We might choose problem situations that are equally general in all our socioeconomic levels of pupils. Second, we might express these problems in symbols that are equally common, and in a manner that is equally motivating, to all socioeconomic groups.

Our position with regard to the present tests may be summarized in a series of four interdependent hypotheses:

1. All responses to all items in all tests of general intelligence are necessarily and inevitably influenced by the culture of the respondent.
2. In a test of general mental ability to be used in the United States, the problems should be selected from the common culture, expressed in cultural symbols common to all native inhabitants of the United States, and selected from that common culture only.
3. In all available tests of general intelligence, however, there are numerous items implying experience that is part of the culture of the higher socioeconomic groups, but not equally a part of the culture of the approximately 60 percent of all Americans who grow up in the lower socioeconomic groups.
4. Therefore, the basic cultural flaws in all available tests of general intelligence may be overcome by including only those problems and symbols that imply experience that is part of the general American culture.

Cultural influences in intelligence tests: The University of Chicago research: Starting with these very general hypotheses, the senior author of this paper originated a large-scale research dealing with "Cultural Influences in Intelligence Tests." The research has been directed by the present authors, with substantial aid from Ralph W. Tyler, W. Lloyd Warner, Virgil E. Herrick, Ernest A. Haggard, Walter I. Murray, and Kenneth Eells. Work was begun in 1945 and will continue for several years. Stated briefly, the aims of this research are:

1. To measure the relative success attained by different socioeconomic groups of pupils

on the specific questions ("items") in eight of the most widely used group tests of general intelligence. This part of the research enables us to identify those test questions that prove relatively easy or difficult for pupils of each socioeconomic stratum in the population. For this purpose, in a Midwestern city of about 115,000 people, all children of ages nine, ten, thirteen and fourteen were tested. To define the socioeconomic status of each pupil's family, we have used a quantitative index recently developed and validated by Warner and Eells. This Index of Status Characteristics correlates highly (over 0.8) with the social-class position of families in Midwestern cities.

TABLE 1

DISCRIMINATION BETWEEN SOCIOECONOMIC GROUPS

TEST	NUMBER OF PUPILS		PROPORTION OF ITEMS SHOWING SOCIOECONOMIC DIFFERENTIAL (PERCENTAGE)
	High Socioeconomic Group	Low Socioeconomic Group	
Given to nine- and ten-year-old pupils:			
Henmon-Nelson	226	322	93
Otis Alpha (nonverbal)	223	316	46
Otis Alpha (verbal)	223	326	70
Kuhlmann-Anderson (Grade III)	225	327	56
Kuhlmann-Anderson (Grade VI)	225	321	85
Given to thirteen- and fourteen-year-old pupils:			
Terman-McNemar	233	361	100
Otis Beta	235	364	91
California Mental Maturity	235	352	69
Thurstone Spatial	235	352	84
Thurstone Reasoning	232	358	100

The results of our item analysis, carried out by Eells, of eight standard, paper-and-pencil group tests of intelligence will be published later in a monograph. For our purpose here, it is necessary only to report the following results: We discovered that a large proportion of the items in each of these tests "discriminated between" children from the highest and lowest socioeconomic levels. In several tests, the proportion on such items was overwhelming; for instance, in the very popular Otis Beta test, 73 of the 80 items on the test showed statistically highly significant differences between the performances of children from the two levels (Table 1).

It will be seen that on only one of the tests did less than half the items show significant discrimination between the two socioeconomic groups, and that on four of the tests, more than 90 percent of the items showed such discrimination. Moreover, the proportion of items discriminating between socioeconomic groups is probably considerably higher in the Otis Alpha tests and in the Kuhlmann-Anderson (Grade III) than our sample reveals. These tests were standardized for grades (and therefore for age groups) that are lower than the mean grade placement and mean age of our sample of testees. We should expect, therefore, that many of the items would be too easy for our sample; such items would not allow the higher socioeconomic group to demonstrate the superiority over the lower in this type of problem. The figures for the California Mental Maturity test are based on only four of the six subtests. Two of the subtests were omitted because the test was too long to give in full in the time available.

The figures indicate the proportion of items that showed a difference between the responses of the two socioeconomic groups large enough to be significant, but they do not show the actual amount of discrimination between the two groups. In order to study the actual amount of discrimination, the percentage of pupils in each socioeconomic group answering the item correctly was con-

verted to an index based on the normal curve. The socioeconomic discrimination of the item was then computed in terms of this index (Table 2).

TABLE 2

AVERAGE AMOUNTS OF SOCIOECONOMIC DIFFERENCE

TEST	AVERAGE DIFFERENCE BETWEEN INDEX FOR HIGH SOCIOECONOMIC PUPILS AND THAT FOR LOW SOCIOECONOMIC PUPILS
Given to nine- and ten-year-old pupils:	
Henmon-Nelson	14.1
Kuhlmann-Anderson	10.3
Otis Alpha (verbal)	6.9
Otis Alpha (nonverbal)	5.9
Given to thirteen- and fourteen-year-old pupils:	
Terman-McNemar	16.4
Thurstone Reasoning	15.2
Otis Beta	14.1
California Mental Maturity	9.9
Thurstone Spatial	9.8

These figures show that the actual amount of difference between the two socioeconomic groups was much greater on certain tests than on others. In general, the tests for the older pupils showed larger differences, although the California Mental Maturity and the Thurstone Spatial tests indicated differences smaller than those found for the younger pupils by the Henmon-Nelson and Terman-McNemar tests. Since there is such wide variation, for the same ages, in the amount of difference between the high and low socioeconomic groups, depending upon what test is used, it is apparent that at least part of the difference must be due to the nature of the material in the tests themselves.

By means of this same index, it is possible to describe any item as showing a "small," "medium," or "large" amount of difference between the high and low socioeconomic groups. Although the definitions of these terms are somewhat arbitrary, they will serve to illustrate the variation in kinds of items in the different tests.

Figure 1 shows the proportion of items with "small," "medium," or "large" differences found in the various tests. It will be seen at once that there is marked variation in the different tests. Nearly half the Henmon-Nelson items, for example, show differences between the socioeconomic groups that are classified as "large," whereas only 3 percent of the Otis Alpha nonverbal items show "large" differences. One-fifth of the items in the Henmon-Nelson show "small" differences, whereas more than four-fifths of the Otis Alpha nonverbal items show this relatively "small" difference. Among the tests for the older pupils, there are likewise marked differences from test to test. In both the Terman-McNemar and the Thurstone Reasoning tests, approximately two-thirds of the items show "large" differences, whereas only one-quarter of the California Mental Maturity items—and only 6 percent of the Thurstone Spatial items—show "large" differences.

This difference between the proportion of each group answering the questions correctly is what we refer to as a socioeconomic differential. It reflects the extent to which pupils from the high groups excel pupils from the low groups on each individual item. The wide variation in the amount of socioeconomic difference found may be illustrated by citing two individual items (see Fig. 2). In the first case, 74 percent of the pupils in the high socioeconomic group answered the item correctly, but only 28 percent of the pupils in the low group did so—a difference of 46 percentage points. In the second case, the percentage answering the item correctly was practically identical for both socioeconomic groups, so that there was no statistically significant difference. The content of these two items suggests the reason for the great variation in their socioeconomic differential. The first item requires the pupil to be familiar with the term "sonata"—clearly a word that will be more often heard in a home in the high socioeconomic brackets than in a family from the low socioeconomic group. The second item, on the contrary, requires the pupil to apply the concept of a "cutting tool" so as to distinguish between this type and several other types of implements common to all socioeconomic groups.

The first major part of our research iden-

tified, therefore, those specific test questions that have proved relatively most difficult for pupils of the lowest socioeconomic group. In doing so, it demonstrated that the standards used for selecting items in present tests have resulted in a very high degree of dis-

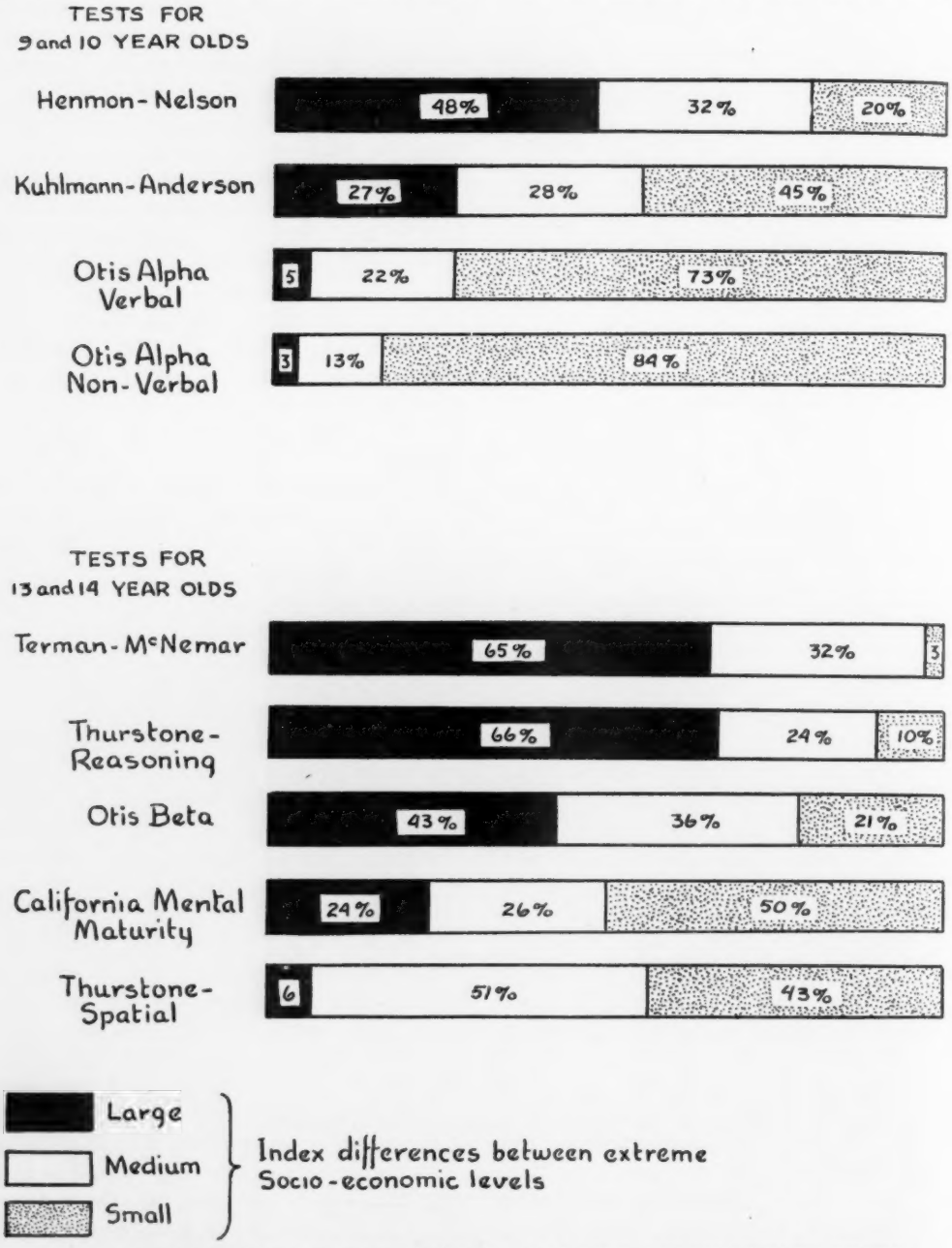


FIG. 1. DIFFERENCES IN RESPONSE TO VARIOUS INTELLIGENCE TESTS

THE LARGER THE BLACK AREA, THE GREATER THE DIFFERENCE IN RESPONSE OF CHILDREN FROM HIGH AND LOW SOCIOECONOMIC LEVELS TO THE PARTICULAR TEST. THE DEFINITION OF SIZE OF DIFFERENCE IS ARBITRARY.

crimination between socioeconomic groups.

2. Furthermore, an analysis was made independently by Walter I. Murray and Kenneth Eells of the relative performance of the highest and lowest socioeconomic groups on different categories, or types, of problems in these tests. Murray and Eells did not agree in their definitions of the types of problems, but each classified the problems upon the basis of the chief mental process that seemed to be involved in the questions, such as "classification of concepts," "recognition of opposites," "recognition of analogies," "syllogistic reasoning," etc. Both researchers found that there was no type of mental problem on these tests that did not show a significant differential in favor of the highest socioeconomic group.

We interpret this finding to mean that the present intelligence tests really measure a very narrow range of mental activities—the range of academic problems. This characteristic of the tests has been recognized by many other researchers. Indeed, the test-makers themselves have used a method of "validating" their selection of problems that insists upon high correlation with scholastic skills.

3. The crux of our problem, however, was to discover why the standard test items proved far more difficult for pupils of the lowest socioeconomic group. To answer this question, we have conducted a large-scale experiment with pupils of ages nine to ten, to measure the relative importance of various cultural influences as between the high and low socioeconomic groups. This central experiment, designed to test the basic hypotheses underlying all the various parts of our research, will be described later.

AT THE biochemical level, the total mental system of a human being must be presumed to be an organization primarily of activities of the brain, the central nervous system, and certain of the endocrine glands, extending only secondarily to the autonomic nervous system. Of this biochemical level, where mental behavior originates, we know very little.

At the level of gross, or molar, behavior,

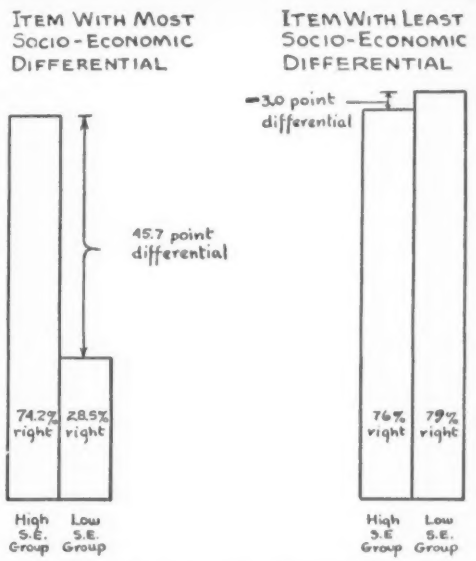


FIG. 2. SONATA VS. CUTTING TOOL

THE HIGH-LEVEL GROUP WAS FAMILIAR WITH "SONATA," WHEREAS THE LOW- WAS NOT. BOTH GROUPS WELL UNDERSTOOD THE CONCEPT "CUTTING TOOL."

however, where observation of learning sequences and records of "conscious" thought are the pertinent phenomena, we may study mental behavior in terms both of learning theory and of measurement.

At this molar level, mental or intellectual behavior is a natural system of phenomena, occurring within the individual organism. It is a system because all mental phenomena function interdependently. Furthermore, all such phenomena interact so as to maintain both processes of change (learning and unlearning) and processes of continuing organization or stability.

Mental behavior, in this molar system, is presumed to result from both genetic and developmental phenomena. The developmental aspects of mental behavior vary according to the amount and intensity of the mobilization (functioning) of the genetic and other organic processes, as stimulated and guided by both the natural and the cultural environments. Most, but not all, developmental mental phenomena, we hold, are learned.

Learned mental systems include a great range of subsystems. One of these subsystems of learning, namely, "problem-solving"

activities, has been made the chief subject of intelligence testing. In every individual's problem-solving activities, his culturally learned acts influence all the other acts and skills in the system. Therefore, no problem in a mental test may be considered to measure mental ability apart from cultural learning.

We assume that the following phenomena enter into the system of acts that constitute a pupil's response to a test problem; they are, therefore, responsible for the status of one pupil on a test, as compared with that of another pupil:

H Hereditary phenomena, determining certain complex organic structural relationships and functional patterns, probably organized by the brain and central nervous system. These hereditary factors are almost never the same in a child as in either of his parents, because the number of possible different combinations of the parents' genes is more than 1,000,000. There is no evidence that such hereditary factors are segregated by socioeconomic levels.

C Cultural phenomena involved in the pupil's degree of experience, obtained in his family or play group, with that particular social environment that determines both the content and the symbols of the test problem.

C_1 Training phenomena in school and home, involving more specific, repetitive, and purposeful experiences with cultural situations and symbols that are closely related to the test problem.

C_2 Cultural motivational phenomena, or "drive"; those rewards and punishments that exist at a level sufficient to impel the pupil to use his full pattern of activities to solve the test problem.

E Emotional phenomena, such as the type and degree of the pupil's anxiety in the test situation.

S The phenomena of "speed," which are complex functions of the hereditary factors, the physical condition and stamina of the testee at the particular time, his cultural habits of work, his familiarity with the cultural form and content of the problem, and his previous experience or training with this specific type of problem.

The relative success of two persons in solving a given test problem, therefore, depends not simply upon their hereditary equipment, but also upon their relative familiarity with the cultural situations and symbols in the problem, their relative degree of training with similar problems, and the relative strength of their motivation. The factor of time may or may not be involved, depending upon whether the test is a speed test or not.

Cultural influences upon problem solving: The lifelong process by which culture helps to guide, develop, limit, and evaluate all mental problem solving has not received serious attention from either testmakers or educators. They continually make the error of regarding middle-class culture, and even more narrowly, middle-class school culture, as the "true" culture, or the "best" culture. More than 95 percent of our teachers and professors are middle-class in their socioeconomic status. Like all other cultural groups, teachers and professors regard that particular version of culture (those mores, emotional patterns, and social values), which they have learned from their middle-class families, friends, and teachers, as the "best" and only "true" culture. This attitude is powerfully reflected in school curriculums, in intelligence tests, and in teachers' judgments of their pupils. It is an attitude that is fatal to the development of the full mental capacity of either the teacher or the pupil. The belief, for instance, that the skills of reading, or writing compositions, and of learning the usual academic materials are the primary essentials of "education" destroys the real aim of education, which is to learn how to think so as to solve life problems. Most schools do not teach pupils how to explore even the simplest real-life problems, how to define their crucial issues, and how to proceed to solve them. The slum schools, especially, seek to teach pupils only how to read, how to carry out memorized, routine arithmetical operations, and how to paraphrase textbooks. Furthermore, intelligence tests seek to predict this kind of behavior; therefore, they include chiefly those problems that are closely related to the culture of the schools.

In acquiring this middle-class academic culture, children of low socioeconomic groups, on the average, do not perform well, either on scholastic tasks or on the intelligence tests that are designed to measure types of learning closely related to scholastic problems.

These low socioeconomic groups fail because their parents themselves have not been trained to read; nor do they regard reading or school curriculums as important. Moreover, neither the parent nor the child's social group urges the child to practice reading or school exercises, nor sets him an example for attainment in this field. The parents and friends of the average child in the high socioeconomic groups, on the other hand, do offer him a powerful example of their skill in reading and in the school type of culture. Furthermore, this latter group of parents consciously and unconsciously reveals an interest in the child's learning this behavior; they likewise afford him practice in such problem solving. For this very reason, Binet and Simon continually stated specifically that reading and other school-type activities were suspect as devices for measuring the intelligence of such children.

This example of reading skill should focus our attention upon the primary role of culture both in identifying those problems that a specific human group regards as important, and likewise in training members of this group to think about such problems. "Culture" means all behavior and thought learned in conformity with a social group. Pupils coming from the top and bottom social strata live in cultures which, though alike in certain fundamental American activities, are yet different in many other cultural habits and motives. At a great many points, therefore, their cultures differ with respect to the types of problems they teach each group to recognize and to solve.

Every human being goes through three essential steps in solving any mental problem. First, he must become aware that there is such a problem. Second, the problem solver must define the essential issues of the problem; that is, he must recognize exactly what type of relationship (such as that of oppositeness, similarity, or analogy) he is asked to discover between two or more variables. (Culture sets and teaches this convention by which the crucial aspects of a relationship are defined. Thus, "opposites" are defined by academic culture as the extremes within a given category or continuum, and not as simply completely unlike concepts. In intelligence tests, moreover, a large proportion of all questions admit of two or more interpretations; only cultural experience with intelligence tests or similar academic problems will enable a pupil even to define the problem as the testmaker requires.)

Third, the individual who solves a mental problem must learn a method, which so correlates the decisive elements of the problem as to reveal their "true" relationship. (Culture states this method for nearly all mental problem solutions, for nearly all human beings. Only one human mind out of millions can discover valid new methods; these in turn are taught by the culture.)

Extremely powerful, then, is the force of culture in determining both the types of mental problems that human groups discover and explore and, second, the methods and skills by which these problems are solved. If the same tests of mental problem solving are to be used with children of all socioeconomic cultures—and this is inevitable in public schools—how is this problem of cultural difference to be solved?

WE HAVE tried to state the general cultural issues involved in any effort to measure the comparative level of problem-solving activities in different individuals. It may clarify our grasp of the issues further if we examine the course actually followed by testmakers with respect to eliminating cultural bias.

Binet and cultural influences: Alfred Binet excelled all his successors both in the realism of his test problems and in his desire to control the cultural aspects of these tests.

Binet made it perfectly clear that he had been greatly concerned over the danger that large sections of his test measured chiefly the effects of cultural training rather than of "mental capacity." He had eliminated certain tests, he wrote, because their solutions could be greatly facilitated by the home or school training of the child.

There are tests which require a knowledge outside the intelligence of the child. To know his age, count his fingers, recite the days of the week indicate that he has learned these little facts from his parents or

friends; we have thought well to suppress these three tests. There are tests too exclusively scholastic, as that of reading and retaining a given number of memories of what has been read, or copying a written model, or writing from dictation. We suppress these.

Even more radical was his decision to eliminate his one test involving reading: "In our new series of tests, that of reading is eliminated, because it belongs to the degree of instruction. . . ." In seeking to avoid problems whose solution could be influenced by either home or school training, Binet went so far as to eliminate questions requiring a child of six years to tell his age, or a child of seven years to copy a sentence, or a child of nine years to "read and retain six facts." Those tests eliminated by him because they had scholastic and other cultural bias included:

Tests of 6 years:	Tell the age.
	Distinguish evening and morning.
Tests of 7 years:	The fingers of the hand.
	Copy a written sentence.
Tests of 8 years:	Read and remember two facts.
	Write from dictation.
Tests of 9 years:	Days of the week.
	Read and retain 6 facts.

Binet then considered the research of Decroly and Degand, which indicated that 47 children tested in Brussels, of "a social class in easy circumstances," showed an average advance in test level of one and one-half years over Binet's "working-class" children. Binet could not face the implications of this fact, when considered in the light of his own views that home and school training influenced the responses to most of his test problems. First, he himself conducted a better and more conclusive research, in which he had M. Morlé test one group of children of high socioeconomic status and another of low socioeconomic status. This research also revealed that the children of low socioeconomic groups did less well on Binet's tests, and that they also did less well in scholastic work. At the same time, Binet pointed out that nearly all the problems in his tests were "correlated" with cultural "aptitudes," which he called "home training," "attention" (motivation), "language," "habit of looking at pictures," and "scholastic exercise."

At this point, Binet stopped reasoning. He simply ignored the facts in making a final estimate of his tests. He could not, or would not, follow through to the obvious conclusion that other kinds of problems were needed. Although he said that these types of training were more highly developed in the schools and homes of children of high socioeconomic status, and although he knew, from his own research, that children of high socioeconomic status had a much easier time with his type of tests, he did not face the clear inference that his tests were not a fair basis for comparing the mental capacity of children of different socioeconomic levels. Intellectually honest and self-critical as he had shown himself to be in his previous work, Binet's failure in this respect may perhaps be attributed to his final illness. Yet his insight into this crucial issue, namely, that of the cultural content and form of mental problems, was far greater than that of subsequent testmakers.

THIS brings us to a consideration of the "mental tests" now widely used in schools. How have the problems in these tests been selected, and what is the evidence that they are valid measures of "mental ability" or of "capacity to learn?" In analyzing these issues, one must remember that, in spite of the vast amount of research done with regard to other aspects of the present tests, there has been no adequate research carried out upon—

a) the choice of a representative cross section of mental systems and problems, or
b) the discovery of problems and symbols that are equally familiar and motivating to all socioeconomic groups, or
c) the discovery of the proportion of items that favor rural as compared to urban groups, or
d) the discovery of the proportion of ambiguous problems having two or more correct answers. (Such problems exist in all present tests.)

How and why have the present problems been selected? Binet, and many of his successors, chose only those problems that were answered correctly more often by "good" pupils than by "poor" pupils. "Goodness" or "poorness" was judged by reference to a pupil's school achievement. A "good" pupil

was one who received high marks in school or who was not retarded in his grade placement. Thus the validity of an item was based upon its correlation with school achievement.

Since testmakers have been unaware of the cultural influences upon both school and test behavior, they have not understood that this method of so-called validation is circular. To prove that a given problem, or test, measures problem-solving behavior, one must find a significant positive relationship between that test and some independent measure of problem-solving activity. But teachers' ratings of pupils are not independent of the activity measured by the standard tests. Consider that the tests include chiefly verbal or picture problems, based upon highly abstract academic concepts. So does the school curriculum. Therefore, a teacher's rating of a pupil is an estimate of the pupil's performance on the same kind of problems as those in the standard tests. Grade placement, likewise, is a measure of a pupil's success on this same kind of academic problem. Neither the teachers' ratings nor grade placement, therefore, may be used as an independent measure against which a test of general problem-solving behavior can be validated.

Furthermore, as Binet himself pointed out, school achievement depends largely upon traits of character, rather than upon mental capacity—upon attention, drive, desire for success in the middle-class culture. Lack of this drive causes the children of low socioeconomic groups to do poor school work. Thus, teachers' ratings are partly an index of work habits and motivation, as well as of mental capacity.

The mistake into which Binet and other testmakers fell, in using grade placement or teachers' ratings, was still more serious, because teachers' ratings differ in their meaning from school to school. Thus a good pupil in a slum school usually is not equal in scholastic achievement to a good pupil in a school for high socioeconomic groups. The teachers' ratings of the former pupil means usually that he is good only as compared with the pupils in that school.

Exactly this error was the cause of Binet's failure. The pupils upon whom he attempted to validate his test all attended schools for working-class children. Thus, his good pupils were not as highly skilled or motivated, for his type of tests, as were pupils in the richer neighborhoods. Therefore, judging the proper age level for a test by his working-class sample, Binet set the age levels of his problems too high. When Decroly and Degand found that children from high socioeconomic groups solved most of these problems at an earlier age, Binet saw his own error. But he was unable to find a way to correct it, for he could not think of any more objective way of selecting problems.

That is, Binet could think of no independent measure by which to judge the validity of his tests. Nor has any testmaker since Binet been able to validate his tests against some other measure of problem-solving activities, which is different in kind. To say, for instance, that a test is a measure of intelligence simply because it correlates highly with another standard intelligence test is to reason in a circle. For all such tests are obviously based upon the same academic type of culture. They correlate highly with one another for the same reason that the individual problems in all such tests also correlate highly with one another and with the test as a whole.

In seeking to justify their selection of problems, testmakers have made arbitrary claims, with no research evidence; or they have grasped at expedients peripheral to the main issue. Terman, when he made the first Stanford-Binet test, followed Binet in choosing only those problems highly correlated with school ratings and school progress. Like Binet, furthermore, Terman selected only those problems that distinguished between adjacent age groups. Whereas Binet considered a problem "normal" for that age group in which 50–60 percent of the respondents answered correctly, Terman's standards for age placement varied more arbitrarily. In Year VIII, he placed some problems that only 55 percent of the respondents answered correctly; in the same year, he placed other problems that 90 percent of the respondents answered correctly—a range of 36 percentage points!

The basic aim in selecting test items should be to control "socioeconomic differentials." For it is the socioeconomic bias in the selection of problem areas and of specific test items that determines, in turn, the "age" differences. Many persons certainly will be astounded by this view. Yet, before rejecting this analysis, they should consider carefully the closely related problem of "sex differences" as handled by testmakers. For problems showing different levels of performance by boys and girls are thrown out by the testmakers!

Why? Terman's remarks are interesting: "This was done for the sexes separately as a basis for eliminating tests which were relatively less fair to one sex than the other."

How can a mental test be "less fair" to boys than to girls? It involves no organic sexual differences, so far as we know. There is here no question, apparently, of different cortical structure, or glandular secretion. Clearly, then, if a question is unfair to boys, as compared to girls, it must be that their social experience is different, on the average. Their training as males or females in the family, school, and play group differs, and therefore the amount of experience they have had with various types of mental problems differs. Their social motivation, as boys or girls, to learn how to solve such problems must also differ. Terman certainly did not believe that girls were genetically superior to boys in mentality, or vice versa.

Thus, upon what must have been a purely social and cultural basis, that is, upon the conviction that any problem was "less fair" if either sex proved "superior" to the other sex in solving it, Terman eliminated all such problems from his test.

Upon exactly the same principle as Terman used to control sex bias in tests, one might throw out all problems in which any socioeconomic group proves superior. There is no evidence, and no theory shared by the leading human geneticists, to the effect that the underprivileged socioeconomic or racial groups are genetically inferior to the more prosperous socioeconomic groups. There is abundant scientific evidence, advanced by sociologists and social anthropologists during the past twenty-five years, that a child's particular social and cultural environment directs, trains, and motivates his behavior. Thus, any differences between the average response of different cultural groups to a mental problem may be attributed to their unlike cultures. Therefore, all problems that show socioeconomic differences in performance should be ruled out of tests as unfair, just as Terman threw out all problems showing sex differences. Both types of differences—sex and socioeconomic—when existing between large groups, may be assumed to be the result of unlike cultural training and not of genetic sortings.

The recent makers of group tests have erred in selecting problems, as a rule, just as did Binet and Terman. For his Alpha nonverbal test, Otis selected only those problems that discriminate against "retarded" pupils. He explains—

> pupils were divided into two groups—a "good group" (in school) and a "poor group"—according to whether the pupils were advanced or retarded for their ages. The value of each item was then investigated as follows: The percent of the "good group" which passed each item was found and the percent of the "poor group" which passed each item was found. Only those items were retained which showed a distinct difference between those two percents.

But we know that those groups of children in elementary schools who are retarded in grade placement are overwhelmingly from the lower socioeconomic groups. Therefore, Otis' method, like Binet's and Terman's, rules out all problems on which the lower socioeconomic groups are superior!

Otis likewise says that he preferred geometric items for the same reason; i.e., they discriminated more clearly against the "retarded" pupils: "Since the first investigation showed a tendency for 'geometric' items to be more valid [i.e., to be relatively harder for low socioeconomic groups] than purely pictorial items, more geometric items were added." To validate the second and third experimental editions of this test, Otis used a "good group," which ranked highest on a composite score: this composite score was based upon a pupil's scores in earlier forms of Otis' tests and upon the pupil's grade-age

position. Both these criteria for selecting problems, of course, also penalize the low socioeconomic groups; for such groups are more often retarded, and the previous forms of the test had been made so as to give them low average scores.

Otis used the same method to select items for his Alpha verbal test. Unlike most other testmakers, however, Otis states specifically that there is a heavy cultural influence in verbal tests. But he does not recommend that his verbal test should therefore not be used to measure the mental ability of the lower socioeconomic groups in the United States.

Otis likewise chose only those problems for his Beta test (grades 4–9) that were easier for those pupils "who were making rapid progress through school" and much more difficult for those pupils "who were making slow progress through school." The same error exists, therefore, in the validation of this test.

Henmon and Nelson used the same kind of circular reasoning in selecting their problems. They explain: "Only such items as proved to differentiate between pupils of known superior and known inferior mental ability were retained." In other words, no independent measure of validity was found.

Edward B. Greene, author of a standard text on measurement, illustrates in a chapter on the selection of test items, the "best method" for selecting items. This method divides the group of pupils (on whom validation is being based) into thirds, judged by their total scores on the experimental form of the test. An item is considered a valid item if a higher percentage of the top third of pupils (judged by total scores) passes it than of the lowest third. Any item on which the performance of the lowest third is as good as, or superior to, that of the highest third is to be thrown out.

Thus, it is impossible to get a range of types of problems in the test. Since the author always starts with academic types of problems, and since the top third of the pupils on these academiclike problems will be chiefly the middle-class pupils, the test inevitably will include more and more such problems. The lowest third of pupils, who will be chiefly in the lowest socioeconomic group, will not be allowed to show, in the final test, any of the activities at which they are superior or equal.

Terman and McNemar selected for their group test only those items which showed: ". . . successive increments from Grades 7 to 9 to 11, in the precentages [of pupils] giving correct responses. . . . The average per cent passing an item for the three grades was used as the final measure of item difficulty." Although they did not use pupils' ratings and grade placement as criteria for selecting items, they got the same result as those testmakers who did. For their group test has a higher proportion of items that discriminate between high and low socioeconomic groups, at age thirteen or fourteen, than either the Otis or Henmon-Nelson.

The reason for this high socioeconomic discrimination is that Terman and McNemar chose a very narrow range of academic problems, all of which were verbal. As we have pointed out, middle-class pupils really are "older" mentally on such problems. Therefore, if one restricts his test to academiclike areas, he will get very high discrimination between socioeconomic groups, even if he overtly selects problems merely because they show age differentiation. He has already discriminated effectively against the low socioeconomic groups by deciding to use only verbal analogies, verbal opposites, syllogisms, etc. He gets significant increases in the percentage of pupils passing such items between grades 7 and 9, and 9 and 11, because the pace of middle-class school and home training increases in such language areas at these ages. Furthermore, since he chooses only those items that show the largest increment, from age to age, in percentage passing, he selects exactly those items relatively easiest for the children of the higher socioeconomic status. For it is the middle-class pupils who are responsible for the big jump in percentage passing this kind of item. As has been said, their progress in verbal school training is accelerating at these ages, whereas the rate of progress of the low socioeconomic groups is decreasing.

Another criterion, used by Terman and McNemar for selecting problems was—

the tetrachoric correlation of each item with the total score based on all three test forms [computed for Grades 7, 9, and 11 separately]. No item was retained which yielded an average tetrachoric correlation [for the three grades] of less than .30 and only 10 per cent of the final items have validities of less than .40. The average coefficient for all retained items was .53.

This is still a circular validation. It does not indicate that the whole test is a representative sample of mental problems, nor does it set up any independent measure of mental ability. It simply says that the test is of one piece. But that is exactly why the test does not measure mental ability; it is restricted to verbal systems of academic problems. Kuhlmann and others likewise have used this criterion of significant correlation between an item and the total score as a basis for selecting each item.

The authors of the California Test of Mental Maturity have stated that they have found "no purely objective criteria" to use in validation. Instead, they have relied upon significant correlations with other tests of mental ability (from our point of view, this indicates that the test is a poor one) and upon "samplings" of "factors."

This second effort to validate follows Thurstone's method. Thurstone himself, however, has depended upon conventional academic types of problems. To select problems so as to obtain "factorial saturations" does not of itself meet the basic requirements for a fair test. First, one must sample a wide range of "factors." One must also, and above everything else, see that the factors are expressed in common cultural symbols. Verbal comprehension, for instance, must be tested in the language of the respondent. If there is a mental factor for verbal comprehension, certainly it is equally distributed genetically throughout all socioeconomic groups. The lower socioeconomic groups, however, talk in their own language, which is a dialect.

By far the best theoretical analysis of the unsound basis of validation used by testmakers has been that of F. Kuhlmann and Rose G. Anderson. These authors see clearly the errors in present tests, and, by common sense, they have done a little to improve them, but nothing to validate adequately their choice of items. They have simply selected those items for which the percentage of correct answers increases most rapidly with age of pupils. We have already shown that this method, when applied to academic types of problems, inevitably leads to the selection of those specific verbal, picture, or geometric problems in which middle-class pupils are most superior.

Kuhlmann and Anderson recognize the bias that exists in the selection of mental areas, and of specific problems.

In selecting tests, the utmost care should be exercised in finding what is universal and common to all in both school and home. The final answer to how near any test comes to meeting this requirement can be reached only through extensive research, of which relatively little has yet been done. The present selection of our tests as regards this factor was done, of course, by inspection. The research necessary to determine this question experimentally would have been far more extensive than all the rest taken together.

Since they have not done this research, they do not know how to get "common problems."

The difficulty of solving the problem of test validity has led to some novel arguments. Thus Terman and McNemar say:

Validity. In the early days of the development of group tests of mental ability an attempt was made to validate them by correlating the scores with teachers' marks. As has been pointed out many times in the intervening years this procedure is unsatisfactory because of the serious shortcomings in teachers' judgments of mental ability. The best evidence of the validity of the Terman test is to be found in its successful use over the period of years since the test was first issued. Many instances may be cited where the Terman test has been used with great success in guidance and administration. In some situations where the use of the Terman test with entering high school students has been made a standard practice, it has been found that year after year those students who graduated with honors were those who made scores in the highest range of the test. The correlation of the revised test with the original test is .91, which indicates that the new test can be considered to be measuring essentially the same basic abilities covered by the original forms.

Exactly what is it that pupils who ranked high on this test have also accomplished? They have received high ratings from their teachers.

E. B. Greene gives the usual definition of

validity: "Thus a valid test of intelligence is one which distinguishes correctly between those who are judged by competent judges, to have various degrees of this ability." In practice, these "competent judges," presumably, are teachers. But what guarantee have we that any group of judges knows, and will be guided by, the basic requirements of (*a*) range of mental systems, and (*b*) cultural communality, of the problems within each area? On the contrary, we know that the "judges" have not recognized these criteria, but have used largely middle-class cultural problems as their guide.

Experimental study of cultural influences: We have now reviewed the methods employed to select both problem-solving areas and also specific items for the present tests, as well as the efforts to validate these selections. These methods, as we have shown, have resulted in tests that discriminate significantly between high and low socioeconomic groups. The crux of our problem, then, is to discover why the present tests have proved far more difficult for the lowest socioeconomic group. In seeking an answer to this question, and following an experimental design set up by Ernest A. Haggard, we have conducted a large-scale experiment with pupils of ages nine and ten, in order to measure the relative importance of various cultural phenomena in test responses, as between the highest and lowest socioeconomic groups. These cultural phenoma were:

a) Cultural symbols (words or pictures) used in test problems.
b) School-training of pupils in related problems.
c) Specific rewards for pupils.
d) Oral vs. written presentation of problem to pupils.

This central experiment, designed to test the basic hypotheses underlying all the vari-

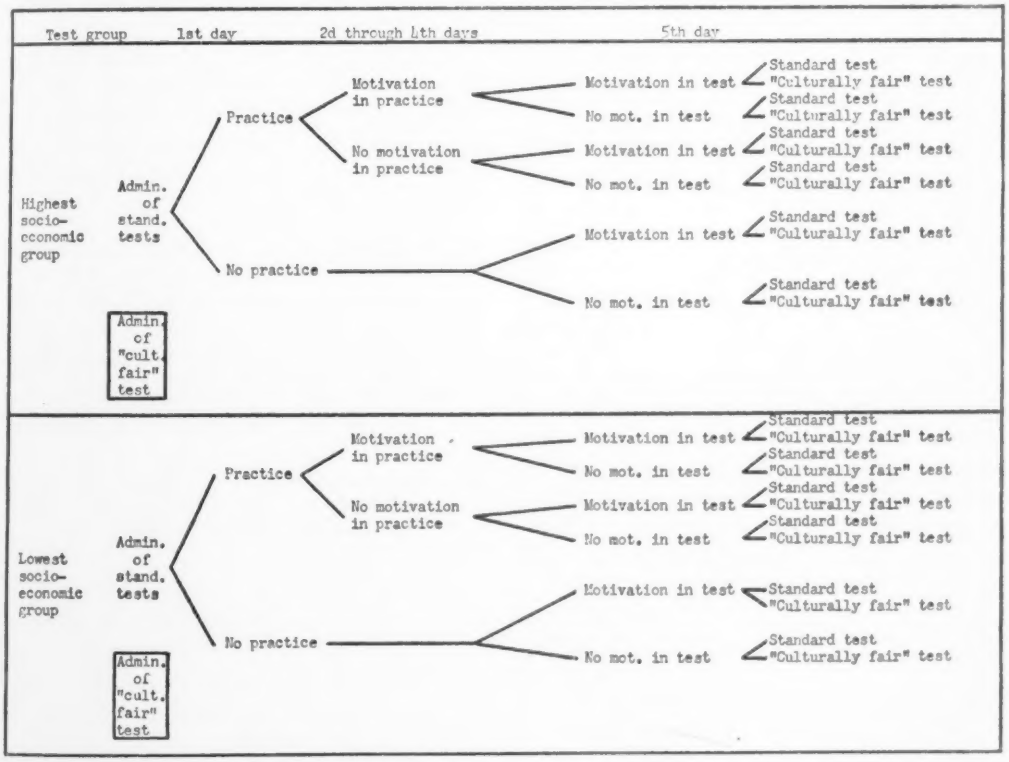


FIG. 3. DESIGN OF AN EXPERIMENTAL STUDY OF CULTURAL INFLUENCES

THIS EXPERIMENT WAS DESIGNED TO FIND OUT WHY CHILDREN OF THE HIGHEST SOCIOECONOMIC GROUP SCORE BETTER IN CURRENT INTELLIGENCE TESTS THAN THOSE OF THE LOWEST. SOME 500 CHILDREN TOOK PART.

ous parts of our research, will be described in a later article, and more fully in a monograph.

Here we may report, however, that we experimented with 516 pupils, equally divided between the highest and lowest socioeconomic groups. Using groups (cells) matched for chronological age, I.Q., and socioeconomic index, we tested pupils with standard test items and also with similar items, which we had made fairer culturally. This testing occurred on a Monday. On the next three days, we gave to half of each test group a total of two hours of instruction and practice with problems similar to, but not identical with, those on the tests. The other half of the testees received no practice.

Each of these halves ("practice" and "nonpractice") had been further divided into half, so that one-half (one-quarter of total sample) received the promise of a movie ticket if they worked hard in the practice sessions, whereas the other half of each practice and nonpractice group were told nothing of a reward. Finally, on the fifth day, half of each such group were told that they would receive a movie ticket if they did well on the retesting that day, and the other half of each cell were told nothing of a reward. Half of all the cells then were retested with the standard tests, and the other half with the "culturally fair" items. On the retesting, two of the cells were given the culturally fair tests orally, so that reading by the pupil was not necessary. Figure 3 may help to clarify the design of this experiment.

Until a detailed report of the analysis is published, it is important to notice for our purposes here that the lowest socioeconomic group improved at the same rate as did the highest socioeconomic group. Motivation during practice decreased the attainment of the highest socioeconomic group significantly, on the standard test items. Motivation during the test helped the lowest socioeconomic group significantly more than the highest. Practice, only, did not help the lowest socioeconomic group significantly on the standard test items, but practice, only, did help the highest socioeconomic group significantly on these items. Both socioeconomic groups performed better on the culturally fair test than on the standard tests, but there was a strong tendency for the lowest socioeconomic group to gain more than the highest socioeconomic group on this culturally fair test. (The items were verbal, paper-and-pencil items.) Finally, it is important to notice that on the culturally fair tests, the lowest socioeconomic group performed better on the oral (no reading) than on the regular (reading) presentation, whereas the highest socioeconomic group did slightly better on the regular than on the oral presentation.

It seems clear to us that if they wish to construct tests to determine the relative mental status of individuals who have grown up in different socioeconomic levels in the United States, the testmakers must take three major steps:

1. They must sample a far wider range of mental activities and thus greatly reduce the importance now given to academic types of problems.
2. They must choose problems that are equally common and equally motivating to all socioeconomic groups, and they must express these problems in symbols that are culturally common.
3. They must discover an objective method of validating their choice of problems, to replace the circular validation now used.

PHYSICAL ANTHROPOLOGY AND RACE RELATIONS: A BIOSOCIAL EVALUATION*

WILTON MARION KROGMAN

Dr. Krogman (Ph.D., Chicago, 1929) assumed, on September 1, the chair of physical anthropology in the Graduate School of Medicine, University of Pennsylvania, after many years as professor of anatomy and physical anthropology at the University of Chicago. He is a specialist in racial differences and prehistoric racial movements in Europe and Asia Minor.

HUMAN paleontologists are agreed that the hominid split-off from a basic Primate stem occurred many millions of years ago. They differ only in their interpretation of just how many millions of years are involved; some go back to the Oligocene, others to the Miocene or even Pliocene. But there is one thing upon which there is now pretty general agreement, namely, that the first fossil hominids, found in the first half of the Pleistocene, dating to only one million years ago, are already quite uniformly assignable to our present genus, *Homo,* even though we still retain the time-honored *Pithecanthropus erectus* and *Sinanthropus pekinensis.* This we may interpret as signifying that basic morphological (osteological and odontological in fossil specimens) characteristics were shared more or less equally by all the then-living hominids. Whatever differences existed were only at specific levels (but I might point out that it has been suggested that the fossil men of China and Java be called *H. erectus pekinensis* and *H. erectus javanensis,* respectively—so that even then differences were possibly at subspecific level). The march of human evolution in the past one million years has been in the direction of a basic morphological and generic identity. From *H. erectus* to *H. neanderthalensis* to *H. sapiens* has been a logical procession that has seen our own species emergent by at least the last 50,000 years and probably somewhat earlier. (There is increasing evidence of a very considerable antiquity for *sapiens* characters.) Be that as it may, we are now in a position to state an important biological fact: all mankind living today—there are no exceptions—belong to the same genus, *Homo,* and the same species, *sapiens.* The biological implications of this fact are as clear as they are simple; that is, that all peoples of the earth are infinitely more alike than they are different. I have used the comparison—more for rhetorical effect than as a precisely determined percentage—that we are 99.44 percent alike, only 0.56 percent different. The percentage ratio may ultimately prove to be 98: 2, or 95: 5, or even 90: 10, but the ratio of biological identities is still a preponderant one.

Let us, then, examine this possible 0.56 percent, this fraction that seems to loom so large in social awareness. I am reminded of a few lines from Shakespeare:

> Strange is it, that our bloods,
> Of colour, weight, and heat, pour'd all together,
> Would quite confound distinction, yet stand off
> In differences so mighty.
>
> —*All's Well That Ends Well,* II, 3

These "differences" that "stand off" as "so mighty"—what are they?

The physical anthropologist, even though he is prepared to accept the fundamental biological equality of man, cannot but believe his eyes—he notes observable differences in external appearance (and, to a lesser degree, in the skeleton) that do in fact permit of a general categorization of mankind, a breakdown below the level of the species.

There are three, or possibly four, great

* From the third annual Charles Sumner Lecture of the Medico-Chirurgical Society of the District of Columbia, Washington, D. C., May 22, 1947.

groups of mankind. These groups, which taxonomically are subspecies, have variously been called "stocks," "major divisions," "ethnic groups," or "races." Obviously, this plethora of terminology has led to some confusion. In the past I have used "stock," but in recent years I have used "subspecies" or, as in this article, "great groups." These great groups, then, are the peoples of Europe, the Caucasoids; the peoples of Africa and parts of Oceania, the Negroids; the peoples of Asia, the Mongoloids; and possibly the peoples of Australasia, the Archaic Caucasoids. Each of these groups is set apart by a fairly uniform (within each group) complex of external traits: pigmentation of skin, hair, eye; form and texture of hair; size and form of nose, mouth, face; certain limb and limb-body proportions; and so on. At the risk of overemphasis it must be stated that it is a *complex of physical traits*—not one, not two or three—that is used in setting up the groups. Any classificatory trait, used singly, is so variable as to lose completely its potential diagnostic value. There is no such thing as trait uniqueness.

The questions may well be asked, When, where, how, why did these natural hominid groups arise? We may give approximate answers to the when and where, but only speculate upon the how and why. It has been suggested that the Mongoloid group stems back to *Sinanthropus* of China, about 1,000,000 years ago; that the Negroid group stems from *H. rhodesiensis* (a Neanderthaloid of South Africa), about 200,000 (?) years ago; that the Caucasoids stem back to early *sapiens*like forms in Europe, possibly 300,000–500,000 years ago; that the Archaic Caucasoids stem from *Pithecanthropus,* about 500,000 years ago. If these assumptions be warranted, then infrageneric variation and selection have a respectable antiquity. In the evolutionary process, however, the universal hominid attainment of species equality is relatively late.

The *modus operandi,* the how, of the differentiation above implied can trace only to genetics, i.e., either mutations or differences in gene frequencies. With generic identity as basic, then it is logical to assume that infrageneric variation is dictated by genetic impulse. Certainly it cannot be denied that today the traits we use in group classification have a genetic basis (even though we still use phenotype, rather than genotype). As to the why, we can only observe that the reason must have been in the direction of adaptation.

In the past, physical anthropologists have made much of "adaptive *vs.* nonadaptive" traits in classification, feeling that the former are useless, the latter dependable. We are now coming to a realization that this is a time-linked problem, that what we are really concerned with is the *rate* of adaptability. The process of evolution is essentially dependent upon adaptability and modifiability, not so much of the whole organism as of its systems and/or parts. There are some, over a period of time, that are more labile than others—these we have called "adaptive;" the others, more resistant to change, slower-rated, as it were, we have called "nonadaptive." Essentially, therefore, it is the limitation of our time-linked finiteness that has given rise to the dichotomy. Be that as it may, we must assume that such differences in man as do exist are part of an adaptive evolutionary mechanism.

It is here that we must come to grips with the possibility that the adaptive differences may have a qualitative value. Recent studies on the skin, for example, seem to confirm the fact that pigmented and nonpigmented skins are, under certain environmental conditions, of greater adaptive value, and hence superior traits, with respect to survival in a given environment. Thus, it may be adduced that a pigmented skin is superior in a tropical clime, a depigmented skin in a temperate one. There may be, and probably are, other such biochemical and/or physiological "superiorities," but it must be emphasized that they are almost certainly directed toward a better biological balance in a specific environment; the traits are integrated into the entire organic response. There is much we do not know of metabolic gradients, physiological variants, biochemical balances, among the peoples of the world. There are undoubtedly many adaptive differences, either in single traits or even in an

entire system of traits. That we still must study and learn.

The foregoing evaluation seems to recognize adaptive biological "superiorities" and "inferiorities." Does this, then, warrant the assumption of "superior" and "inferior" peoples? I would answer with a vigorous No! Again I refer to the fact of biological evaluation (or classification) by an entire complex of traits, not by single traits or a few traits. One physiological or biochemical superiority, aimed at a precise adaptive response, does not permeate into a complete group superiority. I also say No! vigorously because ethnic superiority, as used today, is less a biological, more a social, evaluation. If the physical anthropologist says anything, he says, "There are no biologically superior groups of people." There may be superior *cultures,* but that's another problem.

IF WHAT has been said up to now applies to the three or four major groups of mankind, it applies with equal vigor to the minor divisions of such groups, generally called "races." These divisions within divisions—that are literally at sub-subspecific level—are much less clear-cut, albeit they are, as far as we know, amenable to the same biogenetic principles as are their parent groups. The Nordic race, as an example, is a group of northwestern European peoples representing a type-concept breakdown within the Caucasoid. It is, by its very construct, less clearly defined, far more genetically homogeneous. Again, it has a much more demonstrable record of intermixture, at inter-Caucasoid level, so that although all its constituent members resemble closely the supraparental group, and many resemble the parental group, others may resemble adjacent (Caucasoid) groups with which they were admixed.

It is generally at the level of race that the adjectives "superior" and "inferior" are used. We hear "race superiority" referred to all the time, e.g., *Das Herrenvolk,* the "master race." What the physical anthropologist has said about the larger groups he affirms here: "There are neither biologically superior races nor 'pure' races."

Yet so many groups react to one another as though observable physical differences—the hallmarks of group classification—were of import, somehow, in the entirety of the socioeconomic pattern. The judgment (really prejudgment) seems to be that the measure of physical difference is a yardstick for cultural aptitude. "A man is what he looks like, not what he can do" (if he gets the chance), is the credo of this type of evaluation.

Some years ago I read a poem by Dunsany that to me epitomizes the stealthy, insidious menace of race prejudice. It is called "The Calamity":

> It came without a sound,
> Without the slightest tone
> Of warning to be found
> By which they might have known.
>
> With neither trumpet call
> Nor finger beckoning,
> With nothing said at all
> Aloud or whispering
>
> To wake their faintest fears,
> Beyond what they had read
> Each day for years and years
> And had not credited.

It seems to me that we in the United States have in the past been as blind about race prejudice. It has been there in manifold guises but seen not, heard not, because we did not wish to see or hear. The continuation of such willful sensory denial is calamitous. We cannot, in our role as the champion of freedom throughout the world, continue to be blind and deaf to the menace within our own fold. And, as a matter of fact, I think that in recent years we have made , and are making, exciting and gratifying progress in intercultural relations. Our fears *have* been awakened, and we *are* crediting what we have read, what we have seen and heard.

The genesis of prejudice—for it is acquired, not innate or inherited—is difficult to understand, let alone to trace. In the United States, and with respect to Negro-white relationships, it seems to have had its origin in the socioeconomic imbalance induced by the invention of the cotton gin. There is considerable evidence that the plan-

tation owners of that day, and entrepreneurs generally, rationalized that this vast Negro pool of labor was "destined" to serve by virtue of "biological inferiority." We are told by psychiatrists that prejudice is most often rooted in a more or less subconscious or unconscious feeling of insecurity, of inferiority, which is overcome—at least in part—by a conscious assertion and behavior of superiority. The dominating group achieves a sort of therapeutic relief in its ascendant role. No one would claim that this is the sole factor, but it is probably more basic than we realize.

One may well ask the question, If prejudice is irrational, with no real basis in biologic fact, then what next? The answer, as I see it, is direct and forthright: Educate people to the essential biological facts and integrate that knowledge into the pattern of cultural response. I want to make it clear that I do not envision this as a simple process, or as the major one; nor may one expect an overnight reversal of attitude. We act before we think; we must combine action with knowledge so that action and thought, with respect to race problems, are synchronous.

There are several social processes that will at least ameliorate the intensity of prejudiced feeling. The feeling of socioeconomic insecurity, which is so prevalent in Negro-white relations, can be aided if the white worker realizes that the Negro doesn't demand *his* job, but merely the chance to compete fairly for *one like it*. Today, with nearly 60,000,000 employed, the tension of competition is greatly lessened, and socioeconomic prejudice correspondingly reduced.

Prejudice is lessened if the hallmarks of race difference—the physical traits of skin, hair, nose—are, or become, less obvious. This is a process, involving biological mixture with consequent dominance and recessiveness of certain traits, that has gone on in the United States for some time, so that today the American Negro is a pretty distinctive blend of his African ancestry, white, and American Indian. There is reason to believe, however, that this process of mixture is slowing down, so that it will play a minimal role. Indeed, Du Bois, in *The World and Africa,* says: "I dream of a world of infinite and invaluable variety, not in the laws of gravity or atomic weights, but in human variety in height and weight; color and skin, hair, nose and lip."

There are innumerable instances where active contact and joint participation between the two groups has been its own guarantee of acceptance. The white man on the assembly line, who feared (and because he feared, hated) the Negro who joined him soon learned (as a labor leader once told me) that he was "a reg'lar guy. All he wanted was a job to support his wife 'n' kids, same's me." The exceptions, once made, soon add up to acceptance. In a sense, the group was judged by individuals who, fortunately, were representative of the group to which they belonged.

We have witnessed, in recent years, a very potent factor in the alleviation of race prejudice, namely, the cohesive result of war, a common threat from the outside. At such a time it is not whites, not Negroes, not Mexicans, not this-or-that, but Americans all, rallied and united in a common effort. And the gains in understanding, in sharing, in a more equal participation, must be held and solidified.

When it comes right down to it, such a program is not "radical," "iconoclastic," or "foundation-shaking"—to use some of the evaluations one may encounter. If we accept the essential oneness, the essential humanness, of all mankind, then the human birthright to equality of opportunity follows naturally. The whole issue centers upon human dignity, the dignity of the individual. I must confess I see little that is daring in that, and nothing that we don't preach (on Sundays). The human right to freedom from want; the human right to employment vouchsafing a living; the human right to adequate and decent living and housing conditions; the human right to an education; the human right to equality before the law—these are all to be shared by man, not by men who arrogate specific and special rights to their own group alone. The "son of Man" can know no arbitrary biosocial refinements

which make for inequality, unless we betray and deny our own humanity.

I might well summarize what I have been trying to say in a "Decalogue of Race" that I wrote several years ago. (Alpenfels, E. J. *Sense and Nonsense about Race*).

1. Thou shalt not bow down before the false god of "racial superiority;"
2. Thou shalt not vaunt thyself that only thy race is "pure;"
3. Thou shalt not preach that races or peoples are at different levels of physical development;
4. Thou shalt not claim that racial differences are of fundamental biological import;
5. Thou shalt not establish racial groups as fixed or unchangeable;
6. Thou shalt not, to the detriment of thy neighbor, assert that cultural achievements are based on racial characteristics;
7. Thou shalt not hold that "racial personality traits" are innate and inherited;
8. Thou shalt not demean thy brother because his appearance differs from thine;
9. Thou shalt not, because a man is of a different religion, insist that he belongs to a different race;
10. Thou *shalt* faithfully and sincerely observe the foregoing admonitions and then, indeed, wilt thou love thy neighbor as thyself.

Is it asking too much to practice what we preach? To put biological fact into social interaction?

WHERE SILENCE SINGS

The bats go singing . . . who have ears to hear?
The crystal chants its magic songs below
And lulls male ants to sleep. Aphides draw near
And more prolific grow.

The ant can hear in one small second round
Tone bells vibrating one half million times!
Oh unknown powers of love and light and sound,
Lend me ears for your chimes!

Vibrate them slower, dull have grown my ears;
Ten thousand harp strings strain to catch the sound.
Lift me into the ultrasonic spheres
Where mystic powers abound!

Vibrate my songs, let echoes guide my ways
In sound realms other than my ears have known,
Pulsate the weird, wild music through my days
Until I hear the stone!

ERIS GOFF

A GREAT AFRICAN PROJECT

EDITH TILTON PENROSE

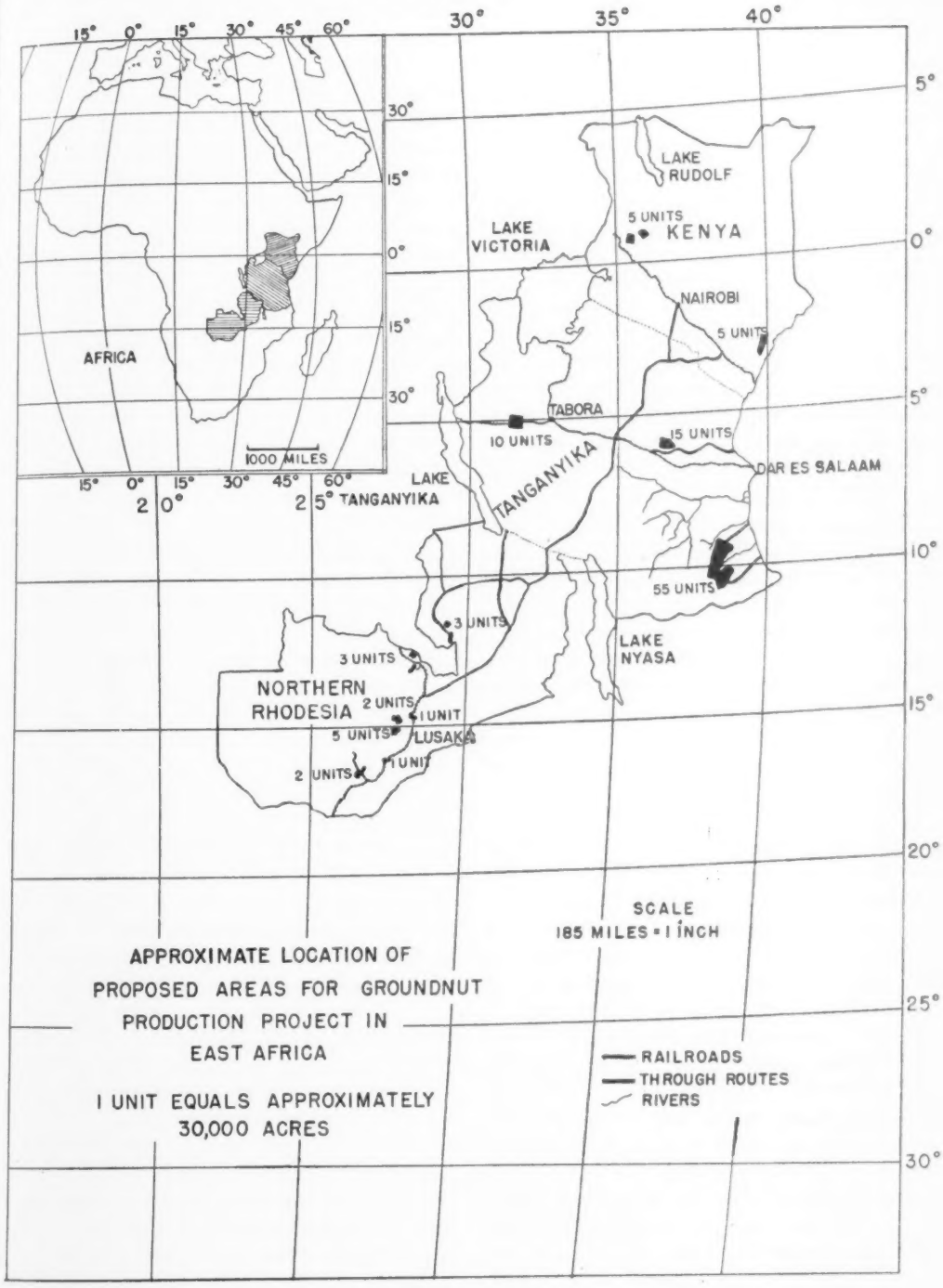
Now studying at Johns Hopkins for her Doctor's degree, Mrs. Penrose has worked with the International Labour Office in Geneva, in London as assistant to the American ambassador to Great Britain, and as assistant to the Advisor on Economic Problems, U. S. Delegation to the Economic and Social Council of the United Nations. She is the author of Food Control in Great Britain *(1942).*

WHILE Americans talk easily of a "declining" British Empire, the British have been going quietly ahead with a great agricultural project in East Africa—a project of immense significance for the development of this area. The government has recently announced plans for the mechanized production of groundnuts, or peanuts, on more than three million acres of land in Tanganyika, Northern Rhodesia, and Kenya, most of which is at present uninhabited, infested with the tsetse fly, and endowed with insufficient ground water even for the domestic purposes of agricultural settlers. The announcement has been enthusiastically received by British government officials, members of Parliament, and others interested in colonial policy and the welfare of dependent people, but it has attracted little notice in this country in spite of its importance for the world food situation and in spite of the interest Americans profess in the colonial policy of other countries.

Today there is a severe shortage of edible fats and oils in the world, of which one of the most important sources is the groundnut, or peanut. This shortage will probably last for many years unless special steps are taken to increase production. In East Africa there are millions of acres of potentially good agricultural land now almost completely uninhabited—controlled not by man but by the bush and the dread tsetse fly, the carrier of sleeping sickness to man and the deadly trypanosomiasis to cattle. The native peoples, equipped with primitive hand tools, with the axe and hand hoe, and using fire to clear the bush, have no chance of making this land productive. Finance, equipment, and technicians are essential for the productive use of this land, so urgently needed not only by the Africans, but at present by the entire world.

In March 1946, Mr. Frank Samuel, the managing director of the United Africa Company, Ltd., presented a plan to the British Secretary of State for Colonies and to the Minister of Food for the large-scale mechanized production of groundnuts in Tanganyika Territory, a British Mandate in East Africa. The government immediately sent out a technical mission to investigate the possibilities of the plan, and in September the mission reported that such a project was agriculturally sound, financially justifiable, and would be of great benefit to the African populations of the areas concerned. It recommended the mechanized production of groundnuts not only in Tanganyika, but also in Northern Rhodesia and Kenya. One hundred and seven mechanized "farm" units of 30,000 acres each were proposed, with villages to house the workers according to healthful modern standards. The possibilities of this type of project for the future of Africa excite the imagination, and the sober British "White Paper" (*A Plan for the Mechanized Production of Groundnuts in East and Central Africa.* London: His Majesty's Stationery Off. Cmd 7030.) in which the project is outlined frequently breaks away from the "official" tone and becomes frankly enthusiastic.

The serious British food position gave the initial impetus to the project, but its greater significance lies in its potential contribution to East African development. And this in turn depends on the way in which the project is carried out. It is clear to the British government that, even apart from any socialist



PEANUTS IN AFRICA

SHOWING IN THE UPPER LEFT CORNER THE LOCATION OF KENYA, TANGANYIKA, AND NORTHERN RHODESIA IN AFRICA AND, TO THE RIGHT, THE LOCATION OF AREAS IN THESE COUNTRIES MARKED FOR PEANUT CULTURE.

ideology, this is not the type of project that can suitably be entrusted to private enterprise. Not only do the amount of capital involved and the scope of the activity required make private enterprise an unlikely sponsor, but the concession of private rights in more than three million acres of African land would be severely criticized today. Plans for the development of the groundnut project are accompanied by plans for the general long-run development of the areas involved in the interest of the indigenous population. And this is properly a governmental function. The initial capital required to finance the project and to maintain it in the early years will come from the British government, but it is planned to transfer the enterprise to the local governments in time and eventually to the African people themselves, possibly on a cooperative basis. Cooperative farming is well suited to the African culture, in which communal agricultural activities have long been carried out, and the project would not be economically practicable if individual subsistence farming should replace large-scale mechanized farming when the enterprise is turned over to native management.

The British government proposes to lease the land from the local governments in the first instance for a period of not less than twenty-five years. The difference between the estimated cost of production of the groundnuts and the estimated world price in the near future is expected to be sufficient to repay the British Treasury for its initial outlay. The management of the project will be provided by a government-owned and -financed corporation with "a responsible Board of Directors answerable to the Government but with the fullest scope for initiative." Until this corporation can be formed, the United Africa Company, Ltd., one of whose officers originally proposed the scheme, will act as managing agent for the government.

In order that no time shall be lost, the project has already been started, but its final scope and the exact method of its execution are still being studied. Scientists and technicians, nutritionists and social welfare workers, doctors, sanitary engineers, and administrators are being sent out to develop the practical details, and all present plans are subject to continuous review as the project develops.

Operations will begin in Tanganyika Territory, where 75 percent of the total acreage will eventually be located—eighty units of 30,000 acres each. The accompanying map shows the approximate location of these areas. Tanganyika lies in East Africa just south of the equator and contains 342,000 square miles. Nearly two-thirds of this area is entirely uninhabitated, and on the remaining one-third nearly six million people are distributed in a highly localized manner. The uninhabited area is largely lacking a permanent supply of domestic water and is covered with a vegetation in which the tsetse fly flourishes. Two-thirds of the total population of Tanganyika are concentrated on one-tenth of its area, and unless the "wide-open" but useless spaces can be brought into productive occupation serious limits are placed on the possibilities of developing the territory and raising native standards of living. Population pressure throughout East Africa is already causing uneasiness to responsible officials, and the development of such large areas in Tanganyika would make possible the absorption of people from other more densely populated parts of East Africa.

The first problem is to clear the bush. The only instrument available to native cultivators is fire. This destroys all organic material, exposes the soil to the baking effects of the sun, and leads to serious erosion, in which much of the ash from burning is washed away. Mechanized bush clearing by means of large tractors carrying bulldozers or treedozers, with subsequent construction of contour ridges and other soil-conservation measures, would eliminate these evils. Soil erosion is one of the most serious factors in East African agriculture, large tracts of land having become desolate and virtually uninhabitable as a result of erosion arising from primitive methods of cultivation. Water conservation and the maintenance of soil fertility are allied problems that could be dealt with by appropriate cultivation and the use of fertilizers, and by rotation of crops. The clearing of the bush will tend to raise the ground-water level, and domestic water sup-

plies will thus be more easily available. Rainfall catchments and storage tanks can be laid down in the absence of sufficient surface or ground water. Under the project, mechanical planting or mechanical harvesting techniques would be adopted, appropriate rotation policies are planned, and after two years of groundnuts the land would be placed under grass, dwarf sorghum, or other suitable crops for a period.

As the volume of production increases, new facilities for handling the produce will have to be installed. These will include a new railway, deep-water berths, bulk storage depots, and port installations in Tanganyika, improved roads and seagoing lighters in Kenya, and improved roads or a new railway in Northern Rhodesia. The development of many parts of Africa is handicapped by inadequate transportation facilities, but in large, unproductive, sparsely populated areas it is difficult, if not impossible, to establish transportation on an economic basis. A large productive enterprise, on the other hand, may make possible the economic development of transportation facilities that will have an effect on the economy far beyond the immediate enterprise.

THE first and most obvious advantage of the project to East Africa is the tremendous increase in the income of the territories concerned that would result from the export of the oil seeds. For Tanganyika alone, under present plans, the total value of its exports would be more than doubled. The income thus available would provide a basis for economic and social development at present lacking. Insofar as the income accrued to the native population directly, it would raise their purchasing power; and insofar as it was made available to the local governments, plans for developing social services and public works could be substantially expanded.

The second obvious advantage is the elimination of the tsetse fly from thousands of square miles. The tsetse fly cannot survive when the bush is cleared. Large areas of Africa were once cultivated by man, who laid the land bare to erosion, exhausted its fertility, and then abandoned it to the encroachment of the bush and to the tsetse fly. To eliminate the fly, man must keep his clearings open. The groundnut project provides an economic basis for the permanent elimination of the bush, and therefore the fly, from large areas—even beyond the actual area of the project itself.

The third obvious advantage is the introduction of modern agricultural techniques on a vast scale. There is no doubt that so long as African peoples are dependent on primitive methods of agriculture it will be impossible appreciably to raise their standards of living without large and continuing subsidies from outside. Many experienced observers of African development are convinced that large-scale modern farming is the only way in many areas to produce enough to maintain or improve the living conditions of increasing populations. The groundnut project itself will not give employment to extremely large numbers of Africans—at the peak of the demand for labor for clearing and for agricultural operations it is estimated that some 57,000 Africans would be employed. When the clearing is completed, around 32,000 will be needed to do the agricultural work. Ancillary operations based upon the project will probably provide employment for more people. Where adequate water is available, livestock on the two-year grass lea, or intensive dairy feeding, using the groundnut tops, might be introduced. Some of the land within the units is not suitable for groundnuts—in Tanganyika, extensive flat bottom lands, or *mbugas*, are too heavy for groundnut production—and these could be used as dry-season grazing grounds for beef cattle or, by using heavy field implements, to produce sorghum grains. Eventually, domestic oil mills could be established to provide for local consumption or, conceivably, when the food position is no longer pressing, for the development of a local plastics industry.

Extensive research activities are envisaged as a part of the project. In the first instance, research in the fields of meteorology, soil fertility, soil surveys and mapping, crop diseases, and variety testing is required. Such research can be planned to provide valuable data on East African soil and crop problems generally. Later, studies of other crops and

of livestock problems linked with the nutritional needs of Africa, and of natural resources and power supplies for industrialization would be included. The White Paper even envisages that "in the later phases the project could turn to the task of realizing the untapped food production potentialities of inner Africa; such as the exploitation of swamps and grasslands, forests, mineral deposits and power resources of the continent on planned and scientific lines."

The development of colonial territories in the interest of the native peoples requires, perhaps more than anything else, the development of the skills and capacities of the people themselves. The groundnut project, properly administered, should be able to make a great contribution to this end, particularly since the eventual goal is the cooperative running of the project by the natives. A permanent labor supply is required, and an opportunity is afforded for the development of communities with adequate housing, medical and sanitary facilities, welfare programs, and educational facilities. Given access to educational facilities and introduced to modern agricultural techniques, the Africans would be enabled to develop skills now extremely rare among them. Of the 24,000 workers who would be required for normal operations in Tanganyika alone, some 5,600 will be in a skilled or semiskilled category. Even this small figure is important in terms of the labor supply of Tanganyika, where African opportunities for skilled employment are very limited. The Africans employed will be encouraged to take the responsibility for running their own welfare services and to participate in the management of the agricultural, commercial, and industrial aspects of the project.

Workers and their families can be accommodated in communities around the project that can provide, in the words of the White Paper, "a model of better standards of living for the African people." The people working on the project should be self-supporting in foodstuffs, and families could probably have access to some land to supply part of their own needs. Research into food production and nutritional needs would be undertaken by the research staff of the project.

Here is a great African program. It is one for Americans to watch with interest, for it is time that American concern with the colonial policy and the so-called imperialism of other countries became more constructive. There are large numbers of people who apparently believe that all colonial policy is "imperialist" in some vague sense and therefore sinister. The motives for every act of a colonial government are examined suspiciously, and the straightforward reasons for it are rejected if some hidden, more devious motive can be elaborated. These critics would do well to examine more closely the trend of British colonial policy in recent years. The chief difference between modern colonial policy and older imperialism is the emphasis in the former on the importance *for its own sake,* of the social, economic, and political development of the native peoples. In all aspects of British colonial policy, this question is prominent. It is not possible for the British government today to plan a purely commercial exploitation of the colonies, even to relieve the domestic food situation.

But in the development of all backward areas, outside capital, technical assistance, and managerial skill are required. The motives for supplying them may be mixed—financial profit, the necessity of obtaining urgently needed supplies, and a simple sense of responsibility for the welfare of dependent peoples will all play a part. There should be no stigma attached to any of these motives, provided that the assistance is rendered in such a manner that the economic, social, and political welfare of the native peoples is advanced. Economic developments in colonial areas are in many ways more significant than political developments, but they should be examined on their merits and not in terms of vague and general political and economic ideologies. The groundnut project is neither socialism nor imperialism. Nor is it private investment for profit. It is an imaginative attempt to develop an extremely backward area of the world in the interest of its own people and of the rest of the world.

RURAL CROSS SECTION

OSCAR LEWIS

Dr. Lewis (Ph.D., Columbia, 1940) compiled the material for this article in 1945, during a three-month survey of Bell County, Texas, under the auspices of the Bureau of Agricultural Economics, U.S.D.A. It is printed by permission of Washington University, which will shortly publish On the Edge of the Black Waxy, *of which this is a brief summary. Dr. Lewis is associate professor of anthropology at Washington University.*

BELL COUNTY, on the edge of the Black Waxy in the western part of the Cotton Belt, contains within its borders much of the diversity and color that is Texas. It is characterized by a great variety in topography, types of farming, ethnic groups, and cultural patterns. The county embraces two distinct and contrasting topographical regions, namely, the Black Prairie and the Grand Prairie Divisions. The line of separation between these two regions runs approximately north and south near the center of the county. The eastern half of the county, in the Black Prairie Division, is a treeless, level to gently rolling prairie, with rich black sticky soils locally known as "black-waxy." This land has made the county famous as one of the best cotton counties in Texas. The western half of the county, in the Grand Prairie Division, is rolling to hilly land, with lighter, sandier soils covered with cedar and mesquite grass. Much of the land is rough and stony, and in some places rises to 200 feet above the surrounding country.

Associated with the striking difference in topography and soils between the eastern and western parts of the county are significant differences in population density, type of farming, levels of living, size of school districts, neighborhood structure, social participation, and the effectiveness of agricultural agencies. This has made for a type of local regionalism that is an important aspect of the life of the county.

The diversity of Bell County is in large part a function of its marginal position, which has exposed it to two distinctive influences, that of the Cotton South and the Cattle West. As in the South, cotton has dominated the economy and has made a deep impression on the life and customs of the people. But the plantation system, which was the core of Southern culture, never took root. This, together with the early importance of stock raising as against cotton growing, was responsible for the development of cultural characteristics distinct from those of the deep South. Indeed, King Cotton never reigned alone in Bell County. The tradition of the cowboy has come down from the early days when stock raising was the major occupation, and today every schoolboy knows that the Chisholm Trail ran through the center of the county. Unlike the deep South, there was no leisure class to romanticize cotton farming, and it could at no time compete with ranching in capturing the imagination of the people as an ideal way of life.*

As in the South, there is an extremely high incidence of tenancy; but unlike the South, there are few sharecroppers. Landlord-tenant relationships are not characterized by the dominance-submission pattern of the deep South, and tenancy carries much less of the stigma of social inferiority. Levels of living, social participation, and leadership do not closely follow tenure lines. In this respect Bell County resembles the West and Midwest.

The absence of the plantation system, the prevalence of family-sized farms, and the fact that Negroes are not basic to the agricultural economy and are but a small part of the

* The people of Bell County generally do not think of themselves as "Southerners" nor as "Westerners," but as Texans. However, they identify with the South when speaking with "Yankees." It is interesting to note that on the eve of the Civil War the county was about equally divided on the issue of Unionism versus Secession.

total population, make for much less rigidity in social controls and the class structure. The relative recency of the pioneer period which, because of the late settlement of the eastern portion of the county, lasted until the early 1900s, has had a leveling influence and gives the county some of the characteristic qualities and spirit of the West. The comparatively high standard of living and educational level is also in contrast with the deep South. Bell County ranks second among thirteen sample Cotton Belt counties in level of living, and ranks first in general educational achievement of both farm and nonfarm people.

Although Negro-white relationships are governed by the folkways of the South, the social structure does not revolve around race relations; and although Negroes are segregated socially and have separate schools, low-income Negroes, Mexicans, and whites may live next door to each other in the towns. Furthermore, Mexican children attend white schools.

The greater ethnic heterogeneity of the population further differentiates Bell County from the deep South. The Czechs and Germans with their distinctive institutions lend a variety to the social structure similar to that found in the West and Midwest. The presence of a number of Catholic, Czech Moravian, German Lutheran, and German Methodist Churches also gives a distinctive quality to the church life of the county.

The position of ethnic minorities in Bell County differs somewhat from both the deep South and the West. In the deep South, where the rate of assimilation is exceedingly slow, ethnic groups tend to form clusters of culture islands. In the Midwest and far West, particularly in Oregon, Idaho, and Washington, where settlement came late and was completed in a comparatively short time, where settlers represented a great variety of ethnic backgrounds and spread out in loosely organized open-country neighborhoods, ethnic differences disappeared rapidly. After a few years, nationality backgrounds became quite unimportant in local life. Bell County can be placed about midway between these two types of ethnic adjustment. Unlike the deep South, the Czechs and Germans of Bell County are becoming assimilated and acculturated at a fairly rapid rate. In this respect they more nearly resemble the West and Midwest. Until recently, however, they were cultural islands and they still live in their own communities and have their distinctive churches and social organization.

The concept of the United States as a melting pot of peoples of different nationalities and cultural backgrounds has been applied almost exclusively to urban areas. As a matter of fact, this process has also been going on in rural areas, although more slowly and less perceptibly. Bell County lends itself to a study of this process, and in this survey we shall compare the customs and value systems of the Czech and German farmers with those of the old-line Americans and wherever possible will indicate the changes that have occurred in the process of Americanization.†

Two other factors have had a very important influence on the life and people of Bell County. The first factor is the presence of Temple, a large urban center, within the county, and the proximity of the county to large metropolitan centers like Dallas and Fort Worth, a hundred miles to the north, and Austin less than seventy miles to the south; the second is the excellent means of communication of the county with the outside, including railroads, good highways, buses, an airport at Temple, a radio station, newspapers, telegraph and telephone. The Gulf, Colorado & Santa Fe and the Missouri-Kansas-Texas railroads run north and south and east and west, respectively, through the county and provide direct contacts with the Pacific Coast on the West, and with the large cities of the East. No town or neighborhood is more than ten or fifteen miles from a railroad, and all railroad stations have Western Union offices. U. S. Highway No. 81 runs through the county and connects with Waco in the north and Austin in the south.

Farmers in Bell County show a Western disregard of distances. Many think nothing

† Throughout this paper the term "old-line American" is used to refer to third-, fourth-, fifth- (or more) generation individuals of English, Scotch, Irish, or Welsh descent, most of whose parents or grandparents came to Bell County from Southern states.

of traveling a hundred miles or more to go on a hunting trip, to attend a football game, or to visit a stock show. The proximity of large urban centers, combined with excellent means of communication, has exposed the rural people to frequent contacts with the Great Society. The townspeople have furthered this trend by making Bell County a cultural center and a meeting place for civic, business, agricultural, and social organizations of the region. The townspeople have also been very active in the support and leadership of farm organizations and thus have been the cultural middlemen between the farmers of Bell County and the outside world. These factors have made for much less provincialism than is characteristic of rural areas in the deep South.

A further word of introduction is necessary. The social organization of Bell County is in a state of great flux. Rural neighborhoods, schools, and churches are changing; new adjustments and integrations are taking place. These processes are occurring on various levels, between town and country, between ethnic groups, and between different parts of the county. In part, this is a result of the recent trends in agriculture toward greater diversification, and in part it represents a delayed reaction to improvements in the means of communication, greater contacts with the outside, and other developments that have had an accumulative effect over the years. In general, the movement has been away from localism and provincialism toward identification with larger groups over larger areas.

Bell County was selected for study to represent one segment of the Cotton Belt, but it also represents a cross section of a functioning bit of America. Negroes and whites, Mexicans and old-line Americans, townspeople and country people, cotton farmers and ranchers, cedar choppers and charcoal burners, rich and poor—all live together under the common political and administrative rubric of the county. While a county study cannot probe as deeply into all facets of life as might a study of a single community, it has the advantage of focusing attention upon the dynamic interrelationships *between* communities, between racial and ethnic groups, between town and country, and between distinctive regions within the county. It is in terms of the interplay of all these factors that the social organization of Bell County is here studied.

IN THIS survey we have attempted to show how the factors of physical environment, history, ethnic composition, and cultural heritage of the farm population have combined to give the rural life and social organization of Bell County its distinctive quality. In the following discussion we shall summarize the role of these factors under three headings: regionalism within the county; the role of cultural factors in farming practices and rural social organization; current trends and problems.

Regionalism within the county. The differences in topography and soils between the eastern and western parts of the county have had far-reaching influence on the social and economic life. In the west, the combination of rolling to hilly land, light, sandy soils, and large wooded areas along narrow river valleys and uplands has made the area particularly suited for livestock and small-scale diversified farming. Since pioneer days this has been the dominant pattern of land use. The distribution of these two types of farming depends largely upon the density of cedar; in the more open country in the southwest, we find a mixed grazing of sheep, goats, and cattle, with cedar chopping as secondary; in the more heavily wooded northwest area, there is small-scale diversified farming based on corn, cotton, and small grains, with cedar chopping and charcoal burning important. In both these subareas only a small proportion of the land is in cultivation, and the sparse population, almost exclusively old-line American, lives along the river bottoms where there is a convenient supply of wood and water. Most of the small wild game that remains in Bell County is found here, and hunting, fishing, and trapping are still important economic activities. Except for the small areas of rich bottom land, the western part of the county is unsuited for mechanized farming.

In the northwest, the farms are small and are generally owner-operated, whereas in the

grazing area of the southwest, ranches are large and are mostly owned by townspeople and operated by tenants or hired labor. In both these areas, the standard of living is low: housing and sanitary facilities are poor (about 30 percent of these farmers have no toilet facilities); and few farms have running water or electric lights. Folk practices have persisted, and many farmers still plant by the signs. Here, too, we find the lowest educational standards in the county.

Localism has persisted in this area, particularly in the northwest, where communities have tended to be more stable and local institutions such as the school, the church, and the store have been retained. In the southwestern part, where tenancy is high and where there has been a greater movement of population, communities and local institutions are much weaker. Throughout the western area, however, there are more one-room schoolhouses, fewer school consolidations, and more hamlet-centered communities than in the rest of the county.

It is interesting to note that the farm families of this area, because of their greater reliance upon subsistence agriculture and their lower standard of living, were better able to weather the depression of the thirties. Agricultural agencies have been least effective in this part of the county, particularly among the poorest farmers—the cedar choppers, charcoal burners, and tenants. Here, too, are the fewest F.S.A. loans, the least soil-conservation work, and the lowest A.A.A. payments for good farm practices. The only considerable payment of A.A.A. money has been for the clearing of cedar and the planting of grasses for sheep and goat raising.

In the eastern part of the county two-thirds of all farm families are concentrated on one-third of the land. The gently rolling, treeless prairie, with its rich black soil, is the center of intensive agriculture and cotton production. Over 85 percent of this land is in cultivation, less than one-third of which is in cotton. During the pioneer period, this part of the county was devoted to stock raising, but since 1880, when the prairie was settled by the Czechs and Germans, cotton has dominated the economy. From 1900 to 1930, cotton occupied about 80 percent of the total planted acreage. Only recently has cotton production declined in favor of more diversified farming and a reversion to the early land-use pattern of stock raising.

The eastern part of the county is characterized by smaller, more town-centered communities, where school consolidation has gone ahead rapidly and local services have declined. The proximity of Temple has contributed to the breakdown of the rural communities and has made for a more urbane population. The Czech and German communities are concentrated in the east. The standard of living is generally higher in this part of the county.

The role of cultural factors in farming practices and rural social organization. Throughout this article I have tried to show the effects of cultural factors upon types of farming and rural social organization. To this end I have compared the customs and value systems of farmers of Czech and German descent with those of old-line American descent. Before summarizing this material it should be recalled that many of the traits here described as typically Czech and German are found in varying degree among some segments of the old-line American population, especially among the small-scale subsistence farmers who live in the western part of the county.

The farmers of Czech and German descent generally have small farms, which they work intensively and carefully. Johnson grass is rarely seen on their farms, and this has given them the reputation in the county of being excellent farmers. They generally have a greater percentage of their farm land in cultivation and grow more of their own foodstuffs and feed for livestock. It is significant that most of the hammer mills for grinding feed are owned by the Czech and German farmers.

In most Czech and German families there is a greater reliance upon family labor—women and children are expected to work in the fields. Among old-line Americans the tendency is to hire considerable nonfamily labor and to gamble between high costs and high farm prices.

The farmers of Czech and German descent seem to have the strongest attachment to

the land and seek security through landownership. Landownership is a more important determinant of status among them than among the old-line Americans. Farm tenancy is lowest among the Czechs and Germans. They also show the lowest percentage of town farmers. Among the old-line Americans the form of tenure is much less important; they seek security for themselves and their children through the operation of larger farms and by taking chances on the cycles of seasons and prices.

Love of the land has made the Czech and German farmers more receptive to government agency programs for the improvement of farm practices. We know that whereas German farmers own or operate only 10 percent of the farms in the county, they represent 30 percent of all soil-conservation district cooperators. Also, boys' and girls' 4-H Clubs in preponderantly Czech and German areas are among the best in the county.

The Czech and German communities are among the most cohesive in the county and have the greatest amount of social participation. Social activities center around lodges, beef clubs, insurance and benevolent associations, beer parlors, dance halls, schools, and churches. The church is particularly important as a unifying force in community life. Unlike most old-line American communities, Czech and German communities are not split up along many denominational lines. Furthermore, there are fewer social cleavages in these communities because of the higher incidence of farm ownership, the greater uniformity in size of farms and incomes, and the presence of large extended families.

The picture presented above is necessarily of a generalized nature. It applies most accurately to the present-day older generation and to the conditions in the county that prevailed twenty-five years ago. Today many families of German descent are thoroughly acculturated, and acculturation and assimilation is going ahead at a rapid rate among the Czechs and the rest of the Germans. The greater contact with the outside that has resulted from the improvement of roads and means of communication, the consolidation of schools, the greater use of radios and the movies, and the experiences of the young men in the armed services in World Wars I and II are some of the factors that have incorporated the farmers of Czech and German descent more and more into the main stream of modern American life.

The drive for a higher standard of living seems to be the key to understanding many of the changes that occur in the behavior and value systems of the Czech and German families in the process of Americanization. As the Czech and German families become more acculturated, there is less emphasis upon thrift and self-denial and more money is spent upon labor-saving devices, household conveniences, clothing, and entertainment. The greater cash income necessitated by this higher level of living has made for a trend toward larger farms and bigger operations, more mechanization, and greater reliance upon hired labor. But the great majority of Czech and German farms are too small to support these newly felt needs, and many of the younger generation are leaving the farms or depending more heavily upon off-farm work. A related trend is a greater reliance upon education as a source of security. A high-school education is now considered the desirable minimum by most farm families irrespective of nationality backgrounds. These changes have also affected the traditional family division of labor. In the more acculturated Czech and German families the women no longer work in the fields, and they assume a role of greater equality with the men in family and community affairs.

Another significant development is the gradual disappearance of the Czech and German language. Czech is still the first language learned by children in most Czech homes, and it is frequently spoken by adults, but practically all Czechs are bilingual. In contrast, German is rarely spoken, although most adults are still fluent in the language. German is no longer used in church services, whereas Czech frequently is. There is growing pressure from Czech youths to have all services held in English.

Intermarriage is steadily increasing despite the resistance of both Czechs and old-line American parents. In the German communities intermarriage with old-line Ameri-

cans has gone farther than is the case among the Czechs.

Current trends and problems. The most noticeable trends are the following:

1. Decrease in rural population: The rural population of Bell County has been on the decline since 1930. The war has furthered this process. At present, approximately 60 percent of the total population of the county is concentrated in three towns—Temple, Belton, and Killeen. This condition will probably persist unless there is an industrial depression with an accompanying back-to-the-farm movement. All evidence points to the fact that a large percentage of the younger people are planning to leave the farm if they can find opportunities elsewhere. The basic reason for this is not dislike of farm life, but dissatisfaction with the low standard of living.

2. Shift away from cotton growing, and related trends: Probably the most significant single change in agriculture in the county in recent years is the marked shift away from cotton growing. In former years cotton acreage was usually 60–80 percent of the total acreage. In 1944, a year in which there was no government restriction on cotton growing, the cotton acreage was less than one-third of the total acreage. It should be noted that the farm labor shortage and the relatively high wages of agricultural workers were contributing factors in the reduction of cotton acreage. Other important and related trends are: (a) more diversified farming, (b) the wider use of cover crops for the improvement of soils, and (c) the increase in livestock both on large commercial livestock farms and on family-sized farms.

3. Fewer and larger farms: The number of farms has decreased with the movement of rural population to the towns. Many farms were abandoned during the war because of the excellent opportunities for off-farm employment within the county. Near-by war industries provided a major source of income for about 50 percent of the farmers.

Since 1930 there has been a steady trend toward larger farm units. In 1940 the average size of farms was 152 acres, an increase of 21 percent over 1930. One-sixth of all farms, principally stock farms in the western part of the county, were over 1,000 acres. However, in the eastern part of the county most farms are still well below 140 acres, which is considered the minimum size for a well-rounded program of diversified farming. The small, uneconomical size of farms is becoming a serious problem among the Czechs, whose average farm is 80–100 acres.

The trend toward larger farms was first given impetus by the A.A.A. Since the war this development has continued with the consolidation of farms, especially in the southwestern area. However, more mechanization was the most important contributing factor in the increase in size of farms.

4. Mechanization: The trend toward mechanization of farms that began in the 1930s has gone forward despite the war. Since 1940, there has been an increase of approximately 500 tractors and 20 corn pickers. There are as yet no mechanical cotton pickers, but some of the wealthier farmers, as well as some of the townspeople, expressed a desire for cotton pickers after the war. If the cotton picker is to come into the county at all, it will have to be a machine of small size. Conditions of terrain rule out any large machinery.

5. Decline of rural communities: A large number of rural communities in Bell County are losing their local services, and the rural population is increasingly going to town for shopping, entertainment, and school. This decline has been accelerated by the consolidation and contracting out of schools, the improvement of roads and means of communication, off-farm employment, movement of farm population to the towns, consolidation of farms, high rate of tenancy, and the improvement of town services.

Rural communities are almost always coterminous with the school district, and the school is one of the most important community institutions. Where the local school is operated, there are generally a greater number of other local services and community life tends to be more active; where the school is contracted out, the community is declining; and, where the school has been consolidated, community life is weakest and there are few local services.

Czech and German communities are the

most tightly knit in the county and have the most active social life. The breakdown of communities is greatest in the southwest where the land has suffered most from erosion. School consolidation has progressed more rapidly in the east because of the greater proximity of the towns.

Of a total of sixty-one communities there are nine trade-centered communities, including Temple and Belton; five village-centered communities; twenty hamlet-centered; twenty-one school-centered; and six store-centered communities. Forty-five rural communities have declined so much within the past two decades that they are now open-country neighborhoods that depend entirely upon town services.

The most important current problems are the following:

1. Farm tenancy: In terms of its long-range effects, tenancy is the No. 1 problem of the county. In 1940, 56 percent of all farm operators were tenants. This percentage has decreased somewhat since the war, but it is still extremely high. Tenancy has existed for so long in the county that it is taken for granted as part of the order of things and generally is neglected as a problem by most government agencies working in the county. Nevertheless, tenancy has been the greatest single obstacle to the spread of improved farm practices. The exploitative use of the land by tenants threatens the very basis of the agricultural economy. This does not mean that tenants are more resistant to culture change than landowners, but rather that the government programs in the county (with the exception of the F.S.A.) were not designed to meet the needs of tenants, who hesitate to improve land not their own. The F.S.A. is the only organization set up to deal with this problem at present. Because of lack of funds it has reached only a very small number of tenants, but as far as it goes, it has been highly successful. What is needed in the postwar period is a greatly expanded F.S.A. program.

2. Soil conservation: Soil conservation is a major aspect of the programs of all the agricultural agencies, such as the Extension Service, Soil Conservation Service, Agricultural Adjustment Administration, and the Farm Security Administration. Since 1939 Bell County has been divided into soil-conservation districts. The work up to the present has been more successful in preventing soil erosion than in improving the fertility of the land. The changes have, on the whole, been limited to landowners and better-to-do farmers. There are elaborate postwar plans for continued soil-conservation work, with special emphasis on soil improvement.

3. Need of farmers' organizations and farmers' cooperatives: At present, there is a lack of farmers' organizations in the county. There is no grange or farmers' union; a chapter of the Farm Bureau was organized recently, but the local reaction was a passive one. Many farmers express the need for farm cooperatives, but in the past their efforts to organize cooperatives have met opposition from town merchants.

4. Need for roads and flood control: The need for better farm-to-market roads is felt especially by the farmers in the eastern part of the county where the sticky black-waxy soils, together with the poor drainage, make dirt roads impassable by car for about five months during the year.

Flood control is badly needed along the Leon River in the western part of the county and along the Little River in the southeastern part. A flood-control project is planned for the postwar period and will probably give employment to a few hundred workers.

5. Need for public-health facilities: Although Temple, Texas, is known as the hospital center of the South, there are inadequate medical facilities in Bell County for the farm population. The shortage of doctors in the small towns and the absence of a county hospital work hardships on the low-income farmers. Some form of health insurance is needed by the farmers in the county.

6. Problem of returning veterans: It is questionable whether any large portion of the 3,500 young men who left the farms for the armed services can be reabsorbed into agriculture in the county. This judgment is based upon the following facts:

a) Despite the exodus of so many young men, farm production has been maintained at approximately prewar levels.

b) The trend toward larger farms and more mechanization has meant a reduction in the amount of necessary farm labor.
c) Many farmers now living and working in towns will, in all probability, return to their farms, thereby limiting opportunities for farming on the part of returned veterans.
d) The present inflated land prices will be a serious drawback to most veterans. Furthermore, most of the best land was bought up by townspeople—doctors, lawyers, and merchants—during the war.

Another aspect of the problem of returning veterans is the question of whether or not they *want* to return to the farms. In the opinion of some informants in the county, a large number of veterans would prefer industrial employment within the county or elsewhere. However, in my survey of thirty-three sample rural communities in the county, it was found that 141 out of 466 returned veterans, or about 30 percent, planned to go back to farming or had already done so. This proportion was higher than anticipated. Of the veterans going back to farming, the highest proportion live in communities in the poorest land areas in the western part of the county, where stock raising and diversified farming predominate. This regional difference in attitude toward staying on the land was also evident in our study of high-school students. Fewer boys from the highly productive black-waxy land areas in the eastern part of the county desire to go into farming.

In the opinion of farm parents interviewed, the only way to ensure the return of the veterans to the farms and to keep the present youth from leaving them is to provide a higher standard of living and more of the conveniences found in towns and cities.

AMEBA

Protean form whose line of ectosarc
Defines the living from the lifeless slime,
A vortex generant of metazoan time
And symbol of our vast primordial dark.

To microvision, gel, and nucleus,
The flow of pseudopod engulfing dust,
Growth and division, struggle to adjust,
Summate ameboid aims subaqueous.

Evolving paradox! Some mutants rose
To stellate beauty, others went
Through gastread and notochordal planes
Where thousand stable types repose.
Itself unchanged! Is this but accident
Or law of subatomic Will to Brains?

JOHN G. SINCLAIR

THUNDERSTORMS

STEPHEN S. VISHER

Professor Visher (Ph.D., Chicago, 1914), long professor of geography at Indiana University, has contributed to The Scientific Monthly, *since 1921, numerous articles, including twelve on various phases of the climate of the United States, with a total of nearly one hundred maps. His latest book,* Scientists Starred 1903–43 in "American Men of Science," *has just been published.*

THUNDERSTORMS are a significant environmental influence in the United States. They are perhaps the most impressive atmospheric phenomenon commonly seen, highly useful in the aggregate, but locally often seriously harmful. The good they do, aside from the often very welcome rain they bring, includes the invigorating drop in temperature, the awe-inspiring display of cloud, wind, and lightning, and the generally stimulating effect of the dramatic change of weather. There is sometimes hail as well as rain.

The harm thunderstorms do includes the squall wind, which usually comes just before the rain begins. This gust may be violent enough to do a great deal of damage. The average annual property loss from "windstorms not tornadoes" in the United States is about $200,000,000. Much of this loss is due to thunderstorm squalls. Often torrential rains fall, with the result that a large share of the water that falls upon sloping ground runs away; much of the soil erosion of our fields is due to thunderstorm rain. "Cloudbursts" not only cause erosion, but they sometimes produce locally harmful floods. The lightning incidental to thunderstorms affords a spectacular display of usually harmless fireworks, but it may do damage. In an average year more than 500 people are killed by lightning in the United States. The hazard to livestock is recognized on every farm. Fires started by lightning annually destroy many million dollars' worth of buildings and crops. It is the cause of many forest fires, with their tremendous losses. Lightning is most dangerous at the beginning of the storm, just after the squall wind, when lightning flashes frequently turn downward. Later, lightning commonly is between parts of the storm, or even upward from the ground.

The lightning of thunderstorms does good as well as harm. Each flash combines some atmospheric nitrogen and oxygen to form ammonia, which, when carried into the soil by rain, adds fertility. Ammonia is an important source of increased fertility in the regions where thunderstorms are common. At the few stations where prolonged studies of this subject have been made, it has been learned that 4 to 8 pounds per acre per year are added thus in England, 6 to 8 pounds in northeastern United States. Lightning flashes also create ozone, an unstable form of three oxygen atoms (O_3). Ozone has a pungent odor and once was credited with "purifying the air"; the claim even has been made that it has a stimulating influence upon mental activity!

Hail, which falls in many thunderstorms, is a convincing proof that the air is cold overhead even in hot weather. It also proves that the updrafts of air that make the imposing thunderhead are strong. Hail does much damage in various mid-latitude regions and on tropical plateaus. In the United States the annual property loss reaches large figures. Detailed Federal estimates are that hail normally reduces the wheat harvest by some 15 million bushels, the oats harvest as much, and the corn harvest by some 24 million bushels. A great deal of damage is also done to fruit, greenhouses, and poultry. Each year some people die in the United States as a consequence of hail bruises, and some hundreds die thus in Europe, Asia, and on the plateaus of Africa.

Thunderstorms are most numerous in the

doldrums or the wet tropics. Severe thunderstorms occur in Brazil, in the Congo basin of Africa, and in the East Indies. They are prevalent throughout the rainy season in parts of the tropics that have a wet season, such as the monsoon region of southeastern Asia and the Sudan of Africa. They are common during the summer months in the parts of the middle latitudes that have summer rainfall; for example, in eastern United States, in Russia, and in eastern Argentina. They occur occasionally in summer in subpolar regions and even in winter over the sea near Iceland. Map 1 shows that in the United States 60 to 80 thunderstorms occur in an average year in each locality in much of the Southeast; 20 to 40 occur in most of the Northeast; and 20 to 50 in most of the West, except along the Pacific coast where there is little summer rainfall and hence few thunderstorms. Thunderstorms occur, however, in spring and autumn in the California type of climate; for example, the vineyards of southern France suffer badly from hailstorms incidental to thunderstorms.

Thunderstorms are the most numerous type of storm, with a world total of about 40,000 per average day, according to C. E. P. Brooks. In the rainy tropics each locality has, as a rule, one a day throughout most of the year, and sometimes two. They are common in summer in most of the United States, where many localities have an average of one or two thunderstorms a week that pass at least within sight of the observer. In most subpolar regions, however, only a few occur, sometimes not one in a summer.

Typical thunderstorms are only a few dozen miles across, and, as they commonly do not live to travel far, they affect only a relatively small area, say, something over 1,000 square miles. In the United States, however, they may travel a few hundred miles and affect several thousand square miles. Their average local duration is only an hour or two. Generally, in the Westerly Wind Belt they travel in an easterly direction, whereas in the Trade Wind Belt they commonly move westward. Their rate of average progress increases with the latitude: it is slow near the equator and usually 10 to 30 miles an hour in mid-latitudes.

Although thunderstorms are predominantly convectional, detailed studies have proved that convection sufficiently intense to cause thunderstorms almost never occurs except where the air is disturbed by at least a feeble cyclonic disturbance, or an air-mass movement. Many of the more intense thunderstorms, especially of the tropics and subtropics, are parts of tropical cyclones.

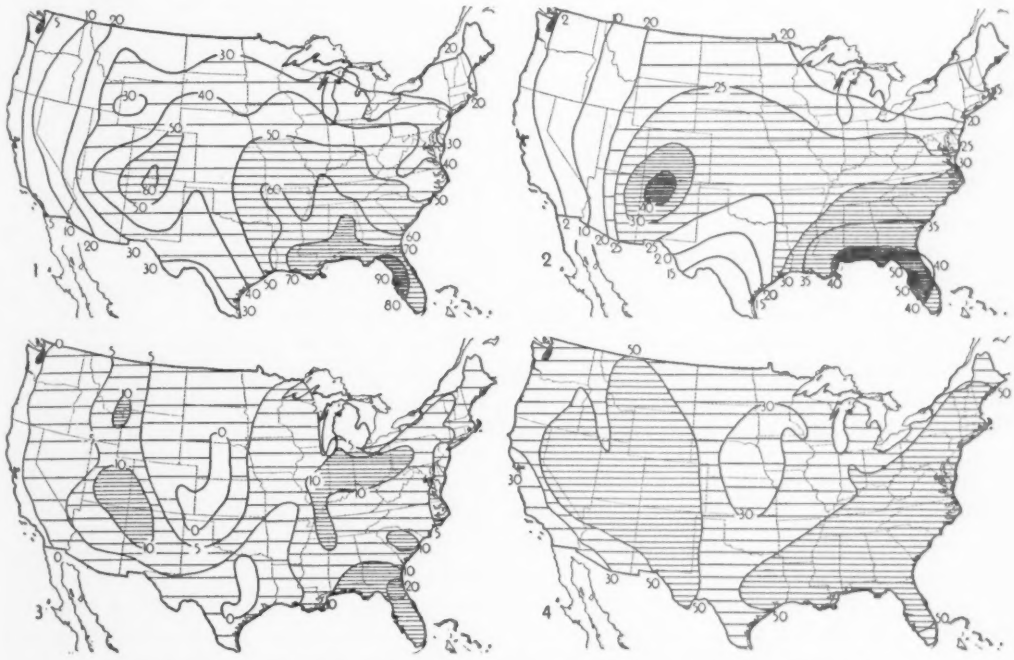
The average summer thunderstorm in the eastern half of the United States yields somewhat more than half an inch of rain; many yield an inch, and frequently one yields more than two inches. An exceptionally intense thunderstorm may yield more than five inches, and a considerable number, especially in the South, have yielded more than ten inches.

The value of the thunderstorm rainfall depends, of course, on when it comes. If, as frequently happens, it comes when it is badly needed, a single thunderstorm may increase the value of the corn yield to the extent of several thousand dollars per square mile. In late August 1947, when this article was being completed, the drought in the Corn Belt was each day reducing the corn yield an estimated 15,000,000 bushels, when corn was selling for $2.40 per bushel. A "good" rain in the critical period of corn growth, following a prolonged dry, hot spell, increases the average yield at least several bushels per acre. Since in the Corn Belt each average square mile has about 200 acres of corn, and since the average American thunderstorm yields rain to a few thousand square miles, a single thunderstorm, under these special conditions, may well be worth millions of dollars. Whenever the Midwest lacks summer thunderstorms, it receives too little rainfall for corn to thrive.

THE foregoing summary suggests that it is appropriate that thunderstorms be seriously studied. Recently, a two-volume mimeographed report on thunderstorms was issued by the Federal government (*Hydrometeorological Report No. 5,* by A. L. Shands and five others), through cooperation between the Weather Bureau, Corps of Engineers of the War Department, and the Soil Conservation Service. Seven of the

eight maps of this article are adaptations of maps in that report.

The present article calls attention to this highly technical, costly Federal report (331 pp., plus 155 illustrations) and presents some of its conclusions. That this article is written by a geographer rather than by a meteorologist reflects the fact that geographers desire to have environmental influences more widely understood. Meteorologists, on the other hand, tend to be chiefly interested in technical phases and write mainly for other meteorologists or for engineers.



FREQUENCY OF THUNDERSTORMS IN THE UNITED STATES

Map 1: AVERAGE ANNUAL NUMBER OF THUNDERSTORM DAYS. *Map 2*: AVERAGE NUMBER OF SUMMER THUNDERSTORM DAYS. *Map 3*: DAYS PER YEAR NORMALLY HAVING TWO THUNDERSTORMS. *Map 4*: PERCENTAGE OF THE SUMMER THUNDERSTORMS THAT OCCUR IN THE AFTERNOON.

Map 1 shows the average number of calendar days per year on which thunderstorms occur in each locality. It is based on the data for 40 years (1904–43) gathered at 217 first-order Weather Bureau stations. It reveals a regional contrast from less than 5 thunderstorms per year along the Pacific Coast to more than 90 a year in part of Florida. East of the Rockies, there is a general southward increase, which reflects the increases in total radiation received, and hence contrasts in the intensity of convection; significant, also, in explaining this general increase southward is the South's longer warm season—thunderstorms occur there even in winter. In the southern two-thirds of the country, there is a general eastward increase in thunderstorms, except that the southern Rockies have relatively many. The general eastward increase reflects the greater moisture content of the air associated with the greater availability of moisture from the Gulf of Mexico. West of the Rockies, where the summers are dry, there seldom is sufficient atmospheric moisture to induce by its condensation the rapid convection required to cause thunderstorms. This is important because thunderstorms feed upon the latent energy freed by condensation.

Map 2, showing the number of summer thunderstorms, indicates that a large share of the thunderstorms occur in the summer quarter. Near the Canadian border, except

in the West, two-thirds or more occur in summer; midway between Canada and the Gulf of Mexico, roughly one-half occur in June, July, or August. Along the Gulf of Mexico, however, somewhat less than one-half occur in that quarter. Likewise in the Pacific States less than half the small annual total occur in summer. In the western mountains most of the thunderstorms occur in summer or near its beginning or end. Map 2 (original) was compiled from the data for each of the summer months.

It frequently happens that there is a thunderstorm in the afternoon and another at night. Map 3 reveals that there is considerable regional contrast in the prospects of 2 thunderstorms in a calendar day. There very seldom are 2 along the Pacific Coast, in the central Great Plains, or in eastern Texas. Conversely, on 10 or more days in an average year there are 2 thunderstorms in a great part of the eastern third of the country and in the Rocky Mountains. Comparison with Map 1 shows that in Ohio, for example, nearly a fourth of the days that have a thunderstorm have 2 of them. Thus, in the areas shaded darkest on Map 3, whenever conditions are favorable for an afternoon thunderstorm, there is considerable prospect that there will be another that evening. The reverse is true of the central Great Plains.

Maps 4 and 5 show the percentage of the summer thunderstorms that occur in the evening or afternoon. Map 4 shows that in more than half the country somewhat more than half the thunderstorms occur in the afternoon (noon till 6:00 P.M., local time). Near the center of the country, however, and in the Southwest, less than 30 percent of the thunderstorms occur in the afternoon.

Map 5 shows that in no part of the country do half the thunderstorms occur in the evening quarter (6:00 P.M. to midnight, local time). In large regions in the West and Southeast, less than one-fifth of the thunderstorms occur in those 6 hours.

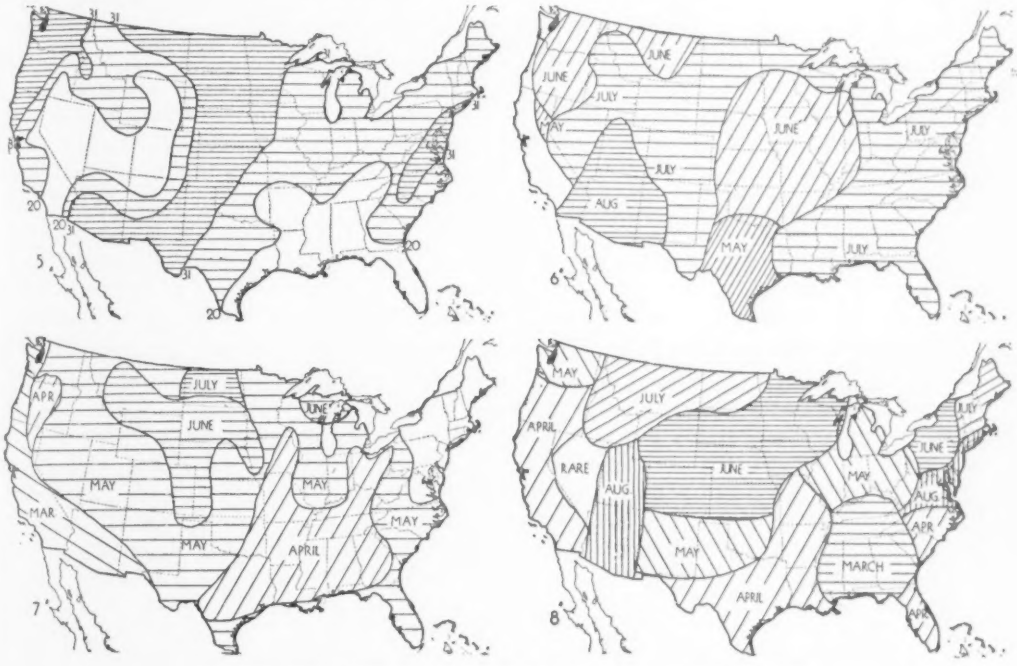
When the percentages of the annual total of thunderstorms that occur in the two periods dealt with by Maps 4 and 5 are added, it is seen that for most of the country only a small fraction—less than one-fifth—of the thunderstorms occur between midnight and noon. The chief exceptions are along the Gulf Coast and in southern Florida, where nearly one-half occur in that half of the 24 hours, and in Wisconsin, where about 40 percent occur then. Coastal California also has approximately one-half of its very few thunderstorms between midnight and noon. These exceptional areas approach somewhat the condition characteristic of the ocean, over which most thunderstorms occur during the night, nearly always shortly before dawn. At that time, as a result of nocturnal cooling of the air the vertical temperature contrast is greatest, since the water's temperature remains almost unchanged. Although eastern Wisconsin is far from the ocean, its temperatures are notably influenced by near-by lakes, especially in warm weather, the time when most thunderstorms occur in that general region.

Map 6 shows the month during which most thunderstorms occur normally. July has most in the eastern third of the country and also in most of the western half; June leads near the center of the country and in the Northwest; August leads in the Southwest; but May leads in Texas.

Hailstorms, although always occurring in thunderstorms, generally are most frequent earlier in the year than the month of most thunderstorms. In the lower Mississippi Valley, for instance, hailstorms are most numerous in April, thunderstorms in July; in Arizona the gap is even greater: March versus August. This gap reflects the greater melting of the downfalling hail in the later month. Observations made from airplanes and on mountains reveal that hail often forms during the warmest months, but generally melts before reaching the valley floors. The latitudinal shift in the month of most hail shown by Map 7 is interesting. (The section at the northeast is left blank on Map 7 because it is complicated, with the month of most hail in various areas in April, May, June, July, and October.)

The final map (8) shows the month of most tornadoes, which, fortunately, are a

rather rare feature of thunderstorms, although practically all occur in thunderstorms, and hence are discussed in the comprehensive report from which this map was adapted. The general latitudinal shift of maximum frequency mentioned for hail occurs also for tornadoes, with interesting modifications. Tornadoes are relatively common earliest (March) from Florida to Kentucky. To the northwest of that area, they are most common in April, May, and June. (Map 7) comes a month later than the month of most tornadoes, although hail occurs near almost all tornadoes. The same month leads for both hail and tornadoes in the Midwest. In Montana tornadoes are more numerous a month later than is hail, but tornadoes are so rare there that the evidence is not statistically strong. The causes for these regional differences in the month of most frequent occurrence of tornadoes are correlated with differences in the depth of warm air. Tor-



THUNDERSTORMS, HAILSTORMS, AND TORNADOES

Map 5: PERCENTAGE OF THE SUMMER THUNDERSTORMS THAT OCCUR BETWEEN 6 P.M. AND MIDNIGHT. *Map 6*: MONTH NORMALLY HAVING THE MOST THUNDERSTORMS. *Map 7*: MONTH NORMALLY HAVING THE MOST HAILSTORMS. *Map 8*: MONTH NORMALLY HAVING THE MOST TORNADOES.

July is the month of most tornadoes for most of New England and from North Dakota to Idaho. August is the leading month in Virginia, along the southern coast of New England, and in Arizona. Comparison of Map 8 with Map 6 shows that in general the month of most tornadoes comes the earlier. The chief exceptions are the areas where the same month leads for both, namely, New England, North Dakota, Arizona, and a central area. In general, the month of most hailstorms

nadoes occur only when the lower air is relatively warm and when a layer of cooler, drier air is not far above the warm surface layer.

THE statement ascribed to Mark Twain that "everyone talks about the weather, but no one does anything about it" is no longer true. During recent months, numerous local rains have been induced by the dropping from airplanes to the top of rain clouds

of a few dollars' worth of frozen carbon dioxide, or dry ice. Although numerous attempts have been made on other sorts of clouds, considerable amounts of rain have so far been induced only if the dry ice is dropped into well-developed thunderheads. Hence, thunderstorms have become significant in yet another respect, by contributing success to man's long-futile efforts to make rain. In thunderheads, the rising air currents that produce the head are almost making rain. But it frequently happens that the cooling caused by the rapidly rising air currents is not quite sufficient to produce enough rain to fall to the ground. Repeatedly, especially during a dry spell, a promising thunderstorm yields little rain. If a quantity of dry ice is dropped into the top of the thunderheads, the sharp cooling it causes produces enough condensation to intensify the convectional rise of air, thus starting a chain reaction that results in considerable rain. At a time when rain is badly needed, the financial returns may be of significant value to a stricken countryside.

Since in the United States thunderheads generally move roughly eastward at somewhat irregular speeds, the dry-ice-induced rain may not fall just where most desired. Its amount depends chiefly not upon the amount of dry ice dropped but upon how favorable local atmospheric conditions are for rain formation. Such induced rain does not deprive some other near-by area of rain. Instead, it is probable that areas subsequently passed over by the cloud, to the east of such a man-made shower, will get more rain than they would have received otherwise. This is partly because the atmosphere contains large supplies of moisture, usually far more than enough above each locality to yield more than an inch of rain. The difficulty is not at all the lack of moisture, but the fact that the air retains its moisture until forced by sufficient cooling to drop it.

The dropping of dry ice on a thunderhead produces rain, not hail. Indeed, it is scientifically highly probable that dry ice dropped into a thunderhead from which damaging hail is falling will cause a reduction of the hail. This is because the dry ice produces a more simple reaction, not the convectional turmoil characteristic of a hailstorm. This turmoil is evidenced by the several layers in most hailstones, indicating that they were carried repeatedly by violent rising currents to great heights.

Since thunderstorms are a major source of rainfall in the United States, and since they are harmful as well as useful, increased knowledge of their nature, occurrence, and possible control is highly desirable.

ON THE DEATH OF A WILLOW IN THE HURRICANE

JULIUS SUMNER MILLER

I knew her in her youth.
I saw her first a sapling,
Young, slender, graceful,
Full with the will to live.
The elements were kind;
The rain fell, the sun shone, the wind blew—gently.
She prospered in God's earth,
Her roots went down, and through them was drawn up
The nurture of the soil.
On this she fattened and her branches spread.
Ofttimes I lingered underneath her limbs,
And sheltered from the blazing sun I looked up
Through the latticework of her leaves,
Geometry against the sky.
On windy days she wrestled with the wind,
Each knowing the other's gentleness,
The wind did not with anger blow
Nor did the tree defy.
It was a sporting game they played.

Years passed. Her girth increased.
Once I could encircle her with hands alone,
And then her bark was smooth and green.
But now her trunk was huge and gnarled,
Her skin wrinkled with the years,
Only her tresses retained the flimsiness of youth,
In every leaf she breathed the joy of living.

And then came an evil day.
For reasons men do not know
God saw fit to bespoil his own handiwork,
To bring ruin to his own achievement and to man's.
The skies darkened, the wind blew, the rain fell;
The storm had come and with it terror in men's hearts.
First, courageously, with some defiance, the willow lashed her limbs;
This was not the playful game of other days;
With every beating she beat back.
She flailed her arms, her branches creaked,
Wrenched first this way, then that.
The torture was too great;
A thousand deaths she lived, and died but one.
From the shelter of the earth her roots were torn away;
Her glory gone, a prostrate form she lay, lifeless,
Her tresses stilled.

Today men came with saws and axes.
Today the wind is silent.
With solemn tribute, as if in prayer,
Nature is quiet in the face of Death.

SCIENCE ON THE MARCH

THE ROLE OF THE RUMEN IN THE NUTRITION OF THE RUMINANT

THE ruminant has a true stomach and in addition three compartments geared by nature to handle fibrous feeds such as pasture grass, hay, straw, and silage. The first stomach, or rumen, has a very large capacity, whereas the second stomach, or reticulum, is nothing more than a pouch of the rumen. It is sometimes referred to as the "hardware" stomach, since heavy objects such as wire, nails, stones, and even gold watches and diamond rings, sometimes swallowed by the large ruminants, are collected in this pocket. The third stomach, or manyplies, presses the feed, but its contribution to the animal is not clear. The rumen and reticulum make one large compartment, sometimes referred to as the fermentation vat, where feed is fermented by fauna and flora. The fermentation vats in animals other than ruminants are the caeca and large intestines, but these animals, such as the pig, horse, and chicken, are handicapped when it comes to handling tough fibrous feeds. The ruminant, on the other hand, is well suited for the job, because of the large size and the position of the rumen. The location of the fermentation vat at the head of the digestive tract gives the bacteria that do the fermenting priority for the dietary factors consumed by the animal. Then, too, the products synthesized during fermentation are efficiently digested and absorbed in the small intestine. The flora in the caecum and large intestine exist on constituents that fail to be digested and absorbed before reaching those portions of the digestive tract.

It is apparent that the efficient fermentation vats of cattle and sheep make possible the utilization of one-half to one billion acres of ranch land in the United States, which otherwise would yield little if any human food. An additional one-half billion acres of land are devoted to pasture, of which only one hundred million acres are plowable. Also, seventy five million acres are devoted to hay crops for livestock feed. These add up to an enormous amount of highly nutritious and palatable food for man. In utilizing these crops, the ruminant contributes to the conservation of one of our greatest national resources—soil fertility. Grasses aid in preventing soil loss. Pasture and hay crops used in rotation, when properly fed to ruminants, aid in building up the soil—thereby contributing to increased yields of grain.

The rumen, which does so much for man, is at last receiving the attention of a few scientists in several different countries. Many different species of bacteria and protozoa and pseudo yeasts have been found in rumen contents.

The feed and water consumed by the mature ruminant pass directly to the rumen. The rapid rate of digestion of a feed of hay is one of the wonders of nature. As soon as the hay reaches the rumen, bacteria begin to bring about disintegration of celluloses and so-called hemicelluloses, so that at the end of six hours most of the feed of hay has been digested. The presence of compounds such as lignin is believed to interfere with the digestion. Highly lignified feeds, at least, such as wheat straw, have very low coefficients of digestibility for cellulose, whereas the cellulose in young grass, beet pulp, and delignified wood pulp is highly digestible.

There are no digestive enzymes secreted by the ruminant, present in the saliva or in the rumen. A few digestive enzymes may come into the rumen with the feed, but these are believed to play an insignificant role in rumen digestion. Although several species of protozoa are present, their function if any is not known. Pseudo yeasts may play a significant role in rumen digestion in some species of ruminants but not in others. Bacteria do most of the work of rumen digestion.

Many species of bacteria have been found

in the rumen. A group referred to as iodophiles, because they take the iodine stain, are the best known. The iodophiles may be small cocci, large cocci, small rods, or large rods. These bacteria penetrate the roughage particles and secrete enzymes that digest the feed for the bacteria. The bacteria absorb these materials and convert them into their own tissues. These bacteria are aided by the host, which, after a good meal, finds a place to rest and chews its cud. The regurgitation of the coarser pieces of roughage enables the ruminant to macerate it by the chewing process. This gives the roughage-loving bacteria a better opportunity to digest it.

The rumen is often looked upon as a storehouse for roughage or a place for digestion to take place. Actually, digestion and synthesis are taking place simultaneously. A few of the dietary factors synthesized in the rumen are: vitamin K, thiamine, riboflavin, niacin, pantothenic acid, biotin, fat, carbohydrate (starchlike compound), protein from nonprotein nitrogen, and unknown dietary factors. The reason that cow's milk is always a good source of most of the members of the vitamin-B complex, regardless of the ration fed, is that they are synthesized in the rumen.

Numerous investigations have shown that rumen bacteria are able to convert urea nitrogen into protein of fair quality. This explains why it is not necessary to consider the quality of protein in formulating rations for ruminants. It is of interest, however, that when the host is fed timothy hay alone, supplementation with urea was without value until starch was added. The replacement of the nitrogen in urea with an equal amount of nitrogen as fish meal increased nitrogen utilization. The addition of the amino acid methionine to the ration of lambs increased the value of the urea as a supplement to a low-protein ration.

It is apparent that the ruminant does not receive the greater part of its nutrients directly from the feed it eats, but from the digestion and absorption of a countless number of food-laden bacteria after they have handled the feed consumed by the host. There is an intriguing theory that postulates the consumption of the nutrient-filled bacteria by protozoa and that the protozoa digest the bacteria and store the nutrients in their own bodies. The host then digests the protozoa. The evidence supporting the theory is that as soon as the animal is fed, the bacterial population increases at an enormous rate, but the protozoal population does not increase until the bacterial population has reached its peak. It is believed that the protozoa wait around until the bacteria have converted most of the feed into their own bodies; then the protozoa fill their stomachs with bacteria. If this theory is ever substantiated, then the animal would be getting its nutrients at thirdhand.

There is some evidence that the vital role of cobalt in animal nutrition may depend on the need of certain bacteria in the rumen for this element. When cobalt is injected into the blood of cobalt-deficient ruminants, the response is very slow, if any. On the other hand, the oral administration of cobalt results in an increase in appetite on the third day, and the recovery is dramatic.

Sometimes cattle suffer from the disease poikilocytosis, characterized by lack of appetite associated with abnormally shaped red corpuscles. The administration of vitamin B_6 brings about recovery. Cows with large open rumen fistula also develop this disease. It is assumed that the rumen flora may under certain conditions lose the power to synthesize vitamin B_6. Occasionally rumen fistula cows lose their appetite and do not respond to cobalt or vitamin B_6 supplementation. In these cases rumen transfusions—the addition of about 50 pounds of normal rumen contents to the rumen of sick cows—have brought about recovery.

The by-products of rumen fermentation are organic acids—principally acetic, propionic, and butyric—and gases—carbon dioxide and methane. It has been estimated that about three-fourths of a pound of acid, calculated as acetic, is produced per day in the rumen of a cow. This amount of acid, most of which is produced during the first few hours after feeding, must be neutralized in order to maintain optimum pH for rumen fermentation. Two methods are used: A cow produces about 120 pounds of saliva daily, which has a pH of 8 and is capable of neutralizing

acid. The saliva, however, has other functions: one is to aid in maintaining a fairly constant water content in the rumen—usually 75–85 percent; it also is a splendid wetting agent and contains an adsorbent responsible for the historical expression referred to in poetry and prose: "The sweet breath of the kine." It is of interest that some of the salivary glands of the ruminant work continuously. The other method of handling acids, and the only one available in the caecum and large intestine, is absorption into the portal circulation through the walls of these fermentation vats.

The gases, principally carbon dioxide and methane, produced during fermentation are eliminated by eructation through the esophagus and to a minor extent by absorption through the rumen wall. Occasionally, however, for some unknown reason, gas elimination stops and bloat takes place.

The advantage of fitting the feed to the needs of the desirable types of rumen bacteria is indicated by the results of several experiments. The feeding of sugar feeds, such as molasses to ruminants, results in a decreased digestibility of the fibrous part of the ration, which is believed to be due to the preference of cellulose-digesting bacteria for sugar. In another experiment, more riboflavin was synthesized by the rumen flora when finely ground corn supplemented a ration of hay than when whole or coarsely ground corn was fed. The possibility of stepping up the tempo of rumen fermentation of roughages is apparent. More knowledge of rumen bacteriology and physiology may revolutionize the nutrition of ruminants, thereby increasing the efficiency in the conversion of roughages to human food.

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ITINERARY*

FIRST ANNUAL INTERNATIONAL PHOTOGRAPHY-IN-SCIENCE SALON

CLEVELAND HEALTH MUSEUM Cleveland, Ohio	March 8–29	THE JOHN CRERAR LIBRARY Chicago, Illinois	June 8–June 21
Science Illustrated New York City	April 6–16	AUBURN CAMERA CLUB Bureau of Animal Industry U.S.D.A. Auburn, Alabama	June 28–July 12
BROWN UNIVERSITY and PROVIDENCE ENGINEERING SOCIETY Providence, Rhode Island	April 22–May 6		
GAMMA SIGMA EPSILON University of Florida Gainesville	May 13–June 1	AMERICAN OSTEOPATHIC ASSOCIATION ANNUAL CONVENTION Boston, Massachusetts	July 19–23

* Reservations for showing the 1948 Salon pictures may be made now. The 1947 pictures will also be available after July 30.

BOOK REVIEWS

SCIENCE AND THE MILITARY

New Weapons for Air Warfare. Joseph C. Boyce, Ed. xvii + 292 pp. Illus. $4.00. Little, Brown. Boston. 1947.

THIS is one of a series of books giving the history of the Office of Scientific Research and Development. The series was introduced by a volume summarizing the activities of the whole organization under the title *Scientists Against Time,* by James Phinney Baxter, 3rd. The remaining seven volumes, of which *New Weapons for Air Warfare* is the first, are grouped under the broadly inclusive title, "Science in World War II." This book gives a running account of the activities of Divisions 4, 5, and 7 of N.D.R.C. and Section T of O.S.R.D.

In late 1940, when England and France were first experiencing the sting of the youthful Nazi Wehrmacht, and the war with Japan was still in its diplomatic phase, the scientific world was rich in knowledge born of research virtually ready for engineering into practical application. The principles of remote control by radio had been demonstrated on toy wagons and flying aircraft by the U. S. Navy. The measurement of distance by timing the flight of radio pulses to and back from the ionosphere was an established procedure, and the more precise location of much smaller objects in three coordinates by similar methods had been demonstrated first by the U. S. Navy, and later and almost concurrently, by the U. S. Army Signal Corps and the British Royal Air Force. Nuclear fission, long predicted by theoretical physics, had been demonstrated in the laboratories of several universities, and the principles of atomic combustion, the basis of the atomic bomb, were known. The necessity for pressing this knowledge into the immediate service of the country for war provided the impelling motive to drive research scientists out of their ivory towers and into the exacting slavery of engineering to specifications. Thus was born the National Defense Research Committee, and later, the child that was made its parent, the O.S.R.D.

New Weapons of Air Warfare contains within its pages much of the drama of personal adjustment incident to the admission of civilian scientists to the military councils of war, to the painful restriction of research personnel to the inexorable demands of engineering specifications, and to the equally painful imposition of the "scientific method" on military personnel conditioned to less scientific precedent. It shows what happens when a tremendous scientific potential, consolidated by patriotic motives, is suddenly released through removal of financial restrictions; how industry may thus be mobilized in a common effort; how duplication of effort may result from planned multiple attack on a problem as insurance against failure of any one attempt, as well as from lack of coordination due either to poor management or to the intellectual isolation of military secrecy; how costly projects are necessarily undertaken on a gamble, the breaks determining whether decision to go ahead was a "stroke of genius" meriting awards and high honors, or an "idiotic blunder" calling for congressional investigation. It gives an inside look at a small part of the fantastically deadly war potential that was about to be released upon the hapless residents of Nippon when the two atomic explosions presented to their war lords a face-saving occasion for surrender.

Multiple authorship is apparent more from variations in literary style and quantity of detail than in outline and organization. In particular, the superlative standards of the first few chapters are never approached in the rest of the book. Although it cannot be said that this does not detract from the main purpose of the book, it is at least partly compensated by the interesting nature of the information presented. If some of the writers in their zeal showed more tendency to repetition than to professional fraternization, it is to be remembered that the achievements

reported truly are phenomenal, and that the book is intended to chronicle the effort of certain divisions of O.S.R.D., and not of the whole country. Most discordant of all, however, is the title itself, since the emphasis of the book is more on antiair than air warfare.

By far the most outstanding feature of the book is the editor's postscript. Here is a gem of purest wisdom, profoundly true and eloquently presented as an appeal to heed the vital lessons whose costly demonstration is so well documented in the pages of this book.

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LEGEND VS. FACT

Alsos. Samuel A. Goudsmit. xiv + 259 pp. Illus. $3.50. Schuman. New York. 1947.

THE myth of Nazi military supremacy was smashed forever by the might of the Allied armies, but the legend of German scientific supremacy lingers on." Thus the author of the book under review introduces his Preface. He later gets evident satisfaction out of presenting the facts that "establish beyond any possible argument" that such German scientific supremacy is *only a legend*.

However, he is less concerned with the fact that "American science" in the field of nuclear physics is found to be superior to "German science" than he is desirous of assessing the factors back of this reversal of the scientific ranking of these two nations.

"Alsos" was the code name for a commission of scientists sent by General Groves to investigate scientific war research in the universities of southern Italy. That unit's success prompted the organization of a larger and more inclusive unit to cover all scientific war research in Germany. The unit was to move into France and Germany as fast as Allied armies occupied those territories. The commission was a joint army-civilian group, headed by Colonel Boris T. Pash for the Army and Dr. Samuel A. Goudsmit for the scientists. Although every aspect of science that related to the war was to be inventoried, actually the greatest concern was with regard to German progress toward the assembly of an atomic bomb.

Headquarters were first set up in Paris, but it soon became evident that effective prosecution of the search for atomic missiles could not be accomplished by such a "remote-control" plan of operations. Very soon operators were in Belgium, Holland, and southern France, running down leads that suggested activities having to do with atomic fission or chain reactions.

The first real "find" was at Strasborg, where they made their initial capture of scientific personnel working on the "uranium problem." At Strasborg the Germans were evidently trying to transform a French institution into a model German university.

The next point of interest and value to the commission was Heidelberg, with its university and Drs. Bothe and Kuhn. At Thüringen they found a "pile" laboratory; at Hechingen, Otto Hahn and Von Weizsacker were picked up, but not Heisenberg, the top-notch German physicist. After the fall of Munich, not only Heisenberg, but the remainder of Germany's key nuclear physicists were at the disposal of the commission.

The commission from the first had assumed that the Germans had a two-year lead in the race to implement the energy from atomic fission into an instrument of fabulously destructive power, for Otto Hahn had revealed the reality of atomic fission, and another German had suggested the probability of a chain reaction in 1938. This assumption received an agreeable negation when the key men had been interviewed and all documents and materials assessed. The facts were found to be:

> Months after our scientists had established . . . the feasibility of the atomic bomb, the Germans were still only talking about the "uranium problem" and the possibility of constructing a "uranium machine." They did not know how to produce a chain reaction in a uranium pile. . . . They did not know how to produce plutonium.

To make up for loss of face in their failure to do what had been successfully done by others, the author says "a theme song" was agreed upon by the interned German nuclear physicists. The refrain of that song was to be: "Germany worked upon the uranium

problem for peaceful uses only; the Allies for purposes of destruction."

In the author's words, the major purpose of his book is to consider "why German science failed where the American and British succeeded . . . [or] that science under fascism was not . . . the equal of science in a democracy." The latter half of the book is devoted to that purpose. In brief, the conclusions are as follows:

> [The assumption] that totalitarianism gets things done where democracy only fumbles along . . . is [far] from the truth. . . . The failure of German nuclear physics can, in a large measure, be attributed to the totalitarian climate in which it lived. . . .
>
> Complacency was one of the worst enemies the German scientists had. Confident of the superiority of German science, they assumed no nation could equal them. . . .
>
> The interference of politicians in the affairs of science . . . the appointment of party hacks to important administrative posts . . . [were] grave errors. [They knew not the wisdom of] leave science to the scientists. . . .
>
> The stubborn blindness of dogma and the free inquiring spirit of science do not mix.

By Gestapo "witch-hunting," which drove "Jewish science" of theoretical physics from the universities, they reduced potential man (brain)-power available for effective work upon the uranium problem.

A "Heil Heisenberg" attitude upon the part of other German physicists restricted maximum utilization of creative production from younger colleagues. "Science is not authoritarian, nor can scientific thought be dominated by a boss."

These factors as contributors to Germany's ill-success are particularized for American science in a final chapter, captioned It Can't Happen Here. The irony of this title is quite apparent before the reader has scanned the first page of the chapter.

It should not be inferred that the book lumps all German scientific participation in the war effort into the same category with nuclear physics. Credit is given for the work done on aeronautics, on submarine techniques near the war's end, and on the V-2 bombs by the army.

For the benefit of the nontechnical reader, an Appendix, An Outline of the Uranium Problem, interprets the vocabulary of nuclear physics.

If, in the course of reading this book, any person senses, upon the part of the author, a note of subjective glee over the failures of the German Nazis, that reader should recall that in the course of his sleuthing for Alsos, Dr. Goudsmit learned "the precise date my father and blind mother were put to death in the gas chamber [in a concentration camp]. It was my father's seventieth birthday."

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CIVIL ENGINEERING

Surveying Instruments. Edmond R. Kiely. xii + 411 pp. Illus. $3.00. Bur. of Pub., Teachers Coll., Columbia Univ. New York. 1947.

SELDOM does a book such as *Surveying Instruments* find its way into the ranks of engineering and mathematics texts. The scholarly excellence of its presentation and documentation alone would have warranted its choice as the yearbook of the National Council of Teachers of Mathematics. Such perfection of presentation makes the history of surveying and its instruments doubly absorbing, even though the history of man's advances in the art of civil engineering as told by the author fascinates the reader in its own right.

Awareness of a code of ethics and adherence to it are counted the distinguishing marks of a professional man. Consciousness of such a status is gained chiefly through the justifiable pride of being a co-partner in a service to mankind that spans the centuries with its scholarly and applied wisdom carefully passed from hand to hand, with each participant striving to add to it. Lack of high ideals and moral stature in those who practice professions lower them to the level of devices used for personal gain. This book provides the spark that will build the fire of professional pride in those who study it.

The value of the book as a text is only heightened by the progressive development of surveying instruments such as the leveling rod, quadrant, theodolite, and the transit from their earliest beginnings in Egypt, China, and Babylonia down through the Greek,

Roman, Medieval, and the Renaissance periods. One achieves a new viewpoint toward what otherwise become commonplace "tools of the trade."

A practical exposition on geometry in schools, followed by a series of well-chosen and well-described exercises in the applications of geometry and trigonometry to simple surveying, completes the text.

In his thirty years of engineering, teaching, and professional experience, the reviewer has never encountered a book that he could recommend so wholeheartedly as "must" reading for all beginning engineering students, teachers of mathematics, and the engineering profession at large.

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MODERN CHEMISTRY

Small Wonder: The Story of Colloids. Gessner G. Hawley. ix + 220 + x pp. Illus. $3.50. Knopf. New York. 1947.

THIS book fills a genuine need in the field of popular science by describing the scientific basis for the behavior of many of the colloidal systems that one meets everywhere in the home, in the factory, and in the hospital. It seeks to inform rather than to baffle and amaze, as is so often the case with "scientific" writing for the general public; but at the same time it is not in the least dull or stodgy, since it furnishes explanations of a sort for so many of the wonders of modern science.

After a fine group of photographs indicative of the scope of the subject, there is a remarkably sound and well-balanced presentation of the fundamentals of colloid science in Chapters 1 through 5 and 11, although in Chapter 5, dealing with the origin and influence of electrical charges, the author all too frequently steps across the narrow boundary between simplification and error. Six additional chapters describe the behavior of representative colloids: milk, rubber, blood, genes, and surface-active agents. These chapters are, in general, well written, although there are a somewhat larger number of technical errors than might have been anticipated, such, for example, as the statements that the most effective industrial catalysts are metal powders, that Conant and Kettering are among the foremost students of the process of formation of proteins in plants, and that solid particles repel water and soft sticky ones attract it. There is, nevertheless, a fine perspective here of our developing knowledge of these and similar systems. Although it would be impossible in a book of this size to devote a full chapter to each of the important colloidal systems, it seems a pity that cellulose, clays, and lubricants could not also have been included.

The chapter on Colloid Chemistry and Life does an admirable job of showing just how the definition of life in terms of capacity to reproduce fails to distinguish adequately between animate and inanimate systems. The terminal chapter on Design for Science might better have been omitted. Who can foresee future advances in any science? It is easy to detail outstanding problems whose existence is recognized—and not all of them concern the origin of life—but it is characteristic that science in its advance discovers *new problems* and then solves them for the ultimate benefit of all mankind.

This book can be heartily recommended to the intelligent general reader, who will be able to derive much satisfaction and enjoyment from it in an increased capacity to interpret his own observations of common colloidal phenomena.

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FAR FROM THE IVORY TOWER

Combat Scientists. Lincoln R. Thiesmeyer and John E. Burchard. Alan T. Waterman, Ed. xii + 412 pp. Illus. $5.00. Little, Brown. Boston. 1947.

SOME of the most brilliant scientific (and a few of the most competent military) brains in this country realized by the end of World War II that the utilization of scientists in staff functions such as operational research and analysis and scientific intelligence is es-

sential to the formulation of well-rounded strategy and tactics. Furthermore, they believe any future emergency will call for a much greater use of military-scientist teamwork in planning and in the field in order to achieve maximum benefits from the ever more complicated weapons under development. On the other hand, many of our military leaders are still far from convinced of the soundness of this reasoning. It is thus particularly unfortunate that *Combat Scientists* does little to present properly, or strengthen, the case for these vital functions of the scientists.

The book is one of the series on the history of the Office of Scientific Research and Development in World War II. Part I of the book, written by Mr. Thiesmeyer, is entitled History of the Office of Field Service. It is dull reading. The detailed account of administrative matters and the short-circuiting of red tape will interest few. The reader is struck by a certain inferiority complex of the Office of Field Service, as brought out in the book by the thrilled use of the words "high level" whenever dealings with anyone above the rank of colonel are mentioned. It does not seem to occur to the author that this was one of the faults of the whole organization. Moreover, the reader is left with no real understanding of what operational research is all about, since not one complete example is given. Not one table or diagram is used. Beautiful examples of the power of operational research do exist. Some way could certainly have been found, within the security regulations, to give the public and rising young military leaders a grasp of this important subject.

Part I belies its title in that it is not truly a history. It gives no consideration to the military side of the picture. Consequently, it furnishes the military student no means of evaluating the thinking behind the many struggles that ensued as the armed forces wrestled with the question of the wisdom of admitting scientists to staff work in Washington and staff and field work in the theatres of war. No mention is made of the career risks assumed by the handful of farsighted officers who pioneered in the introduction of civilians into war planning. The failure of the book to give the rising generation of officers the background history of the valiant action of these men within the services, which led up to such disarmingly simple statements as "at the request of Admiral Blank such and such was initiated," leaves a tremendous void. This makes necessary a whole new military educational process that will have to be undertaken along such lines by the Research and Development Board.

A particularly bad paragraph is to be found in the Lessons for Tomorrow chapter. It recommends the establishment of an organization such that in the event of a national emergency any research scientist could be drafted from his work and sent to theatres of war for field assignment at the mere request of the Field Service office, which request would

> carry the force of directives from the top. . . . Progress of research and development, even on what were considered crash programs this time, was far too slow to warrant keeping our best brains at work in the laboratory on things that might not be ready within the few weeks or months the next war lasts.

If there is any lesson we should have learned from the Germans in this war, it is that taking scientists out of research laboratories just because it is believed the war "will be a short war" is the best way to lose our homeland. Consider the atom bomb, microwave radar, and biological warfare from this standpoint.

Part II consists of a live account by Mr. Burchard of two endeavors undertaken by the Office of Field Service scientists. The problem of furnishing navigational aid to amphibious landing operations is shown to be the type of job on which scientists could be eminently successful despite heartbreaking delays. Many lives were saved through their unsparing efforts. By way of contrast, the second example chosen is that of a complete failure. The task in this instance was to develop a method of clearing enemy beaches of obstacles to landing operations, such as concrete piling, rails, etc. Mr. Burchard weaves skillfully the cobweb of difficulties and lack of ideas that enmeshed this undertaking. In the end, men had to swim in to enemy beaches and sacrifice lives in placing charges to clear the way for their buddies in landing barges.

It is recommended this book be read widely. It is hoped that out of such study there will arise a more scholarly analysis of the challenging and still-unsettled problem of the optimum method of utilization of scientists in military staff planning and in theatre-of-war assignments.

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Arthur D. Little, Inc.
Cambridge, Massachusetts

IN ENDLESS FILE SHALL LOVING SCHOLARS COME

Louis Agassiz, Scientist and Teacher. James David Teller. xi + 145 pp. (paper). Graduate School Studies, Educational Ser., No. 2, Ohio State Univ. Columbus. 1947.

AN AURA of intermingled fact and fable always hovers over our national heroes, great or small. Louis Agassiz was no exception, but there is no fiction to his greatness, either as a scientist or as a teacher; and Dr. Teller, in this scholarly yet readable study, has performed a service in summarizing and re-emphasizing Agassiz' contributions to science and education. Its publication nearly coincides with the centennial of Agassiz' coming to America and with the diamond jubilee of the establishment of his famous marine biological laboratory on Penikese Island near Woods Hole, Massachusetts.

Agassiz' students were like stars in the sky—almost as numerous and some of them nearly as bright. In the last century, especially from the sixties through the eighties, they studded the faculties of American schools and colleges the country over, adding luster to their master's name and keeping alive his methods of teaching.

One of Agassiz' students, the later illustrious William James, said of him:

> He was so commanding a presence, so curious and inquiring, so responsive and expansive, and so generous of himself and of his own, that everyone said of him: "Here is no musty savant, but a man, a great man, a man on the heroic scale, not to serve whom is avarice and sin!"

This indeed is a strong encomium, but we must believe it, for the record shows that every one of Agassiz' students felt the same way. Though his pedagogic method to us may seem a little hard—("There is probably no public school teacher now in New England," wrote James, "who will not tell you how Agassiz used to lock a student up in a room full of turtle shells, or lobster shells, or oyster shells, without a book or a word to help him out till he had discovered all the truths which the objects contained")—Agassiz won every student to him by his irresistible personality and his ultimate rectitude. One of them still survives—Edward A. Birge, president emeritus of the University of Wisconsin, in his ninety-seventh year.

Agassiz left his mark on many phases of education, and Dr. Teller elucidates them all—on the development of museums, on the summer-school idea, on the study of natural history, on the nature-study movement, on laboratory instruction, on the lecture method, on the university in general. Everyone interested either in the history of science in America or in the history of education will want a copy of this booklet. He will learn a great deal from it, and marvel that even yet the incredible spell of Louis Agassiz has not passed away.

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INTERPRETATION OF SCIENCE

The Scientists Speak. Warren Weaver, Ed. xiii + 369 pp. $3.75. Boni & Gaer. New York. 1947.

IF FOR no other reason, this book would merit reading on the basis of having so distinguished an editor and list of contributing authors—including eight Nobel prize winners, seven directors of prominent American research institutions, three university presidents, and many other leaders in science and education. And the content of the book lives up to what one might expect from men of this stamp.

The volume is a collection of the radio talks on science that formed the intermission program of the New York Philharmonic-Symphony broadcasts sponsored by the United States Rubber Company. The Preface to the volume, written by the Advisory Committee for this program, stresses the

fact that the talks were built around men rather than around subjects. It was the intention of both sponsors and Committee that outstanding leaders in science should be asked to describe as intelligibly as possible their own fields of work and tell what they felt was significant for the layman. Without exception, they have succeeded in a most gratifying way. The talks, changed but little in their transition to the printed form, are of necessity brief—two to four printed pages each. It is a delight to see how great a vista of a given field of research can be presented in such small space; yet one never gets the impression of being hurried through a topic. Those who heard some of the talks will probably concur with this view.

The Committee has maintained a fine balance between the various scientific fields, and as a result the work is bound to interest everyone who desires an acquaintance with the problems of greatest present interest in science. It is remarkable, too, how almost every author unobtrusively weaves in the background needed to appreciate the problems of the hour. One of the most valuable features of the collection is the introductory chapter by Dr. Weaver—a skillful appraisal of the status of science and the tasks before it today. Equally helpful are his brief introductory pieces heading the main divisions of the book.

No undertaking of this magnitude can be completely free of blemishes, but very few were found, and none of these seemed serious. A chemical engineer and a physicist appear to contradict each other on the virtues of synthetic rubber (pp. 67, 85), and a medical researcher makes the statement that "the spectroscope operates on the principle that the color of an object depends upon its absorption or reflection of light."

The simple clarity of exposition in these articles bears out a conviction long held by this reviewer: that the best interpreters of science, today as in the past, are the men who lead the research itself—if only we could persuade them to do more of this type of writing. Our country seems to be one of the few where the bulk of interpretative science writing is left to journalists. Several of our science writers do a uniformly good job, but their number is pitifully small. In the European newspapers, for many decades, the practice has been to ask top-flight scientific workers to write expository articles for use in the *Feuilleton* or *Unter dem Strich* portion of the paper (which, by the way, was on page 1). There must be many men of the caliber of Eddington, Jeans, Gamow, and Hecht who are equally skilled in uncovering truth and talking about it simply and interestingly. Some of the contributors to the present volume may well be included in such a list.

IRA M. FREEMAN

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EARLY AMERICANS

The Indians of the Americas. John Collier. xi + 326 pp. Illus. $3.75. Norton. New York. 1947.

RARELY does one find the combination of careful scientific work and gifted writing that one meets in John Collier's book, *The Indians of the Americas.*

Beginning with the earliest evidences of man's culture in the New World (even pushing back into its Asiatic antecedents) and following through to the ultimate future of prediction, Collier traces the American Indian, his way of life, and his philosophy. He gives the reader a sense of continuity often lacking in the view of the Indian. He interrelates the various Indian cultures. Too often in the past these cultures have been treated as separates, with their historical continuity obscured.

The book is divided into four parts. Part One presents the Indians of prehistoric times; Part Two presents the Incas, Aztecs, Spanish conquest and rule, and the Indians of the Republics; Part Three presents the Indians of the United States; Part Four deals with the future.

The book is based on solid fact. Its author has had long experience as a research worker and a practical administrator. One recognizes this experience combined with a deep sincerity and intensity of purpose.

In this book the Indian emerges as a man. His achievements appear as a part of man-

kind. If no other end had been attained than this one of placing man in the New World in the perspective of man in the total world, the book would have been valuable. But it does more than that. It gives a clear, integrated picture of the Indians of the Americas. Time and space are used to clarify, not to bound or limit. The solution to modern world problems is the main goal.

ETHEL G. AGINSKY
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NEO-FREUDIAN

Conceptions of Modern Psychiatry. Harry Stack Sullivan. vii + 147 pp. $2.00. William Alanson White Psychiatric Foundation. Washington. 1947.

IN THE past few years, several psychoanalytic writers have offered major modifications in the theoretical structure of traditional Freudian psychoanalysis. In this series of lectures, Dr. Sullivan, a leading psychoanalyst, has done more than this. As a result of his experience in teaching, treatment, and research, he has evolved a set of principles concerning the nature and development of personality which, although they would probably never have been developed had psychoanalytic thought not been available, differ very radically from the tenets of traditional analysis. The importance of childhood events and the transfer of their effects to later life, as well as the notion of unconscious processes (here called "dissociation"), remain in Dr. Sullivan's formulations, and these points portray, of course, some of the debt he owes to Freud.

Some of the writing in the present volume is difficult and technical, and in general Dr. Sullivan's style does not make for easy reading. The relatively uninformed reader will find Mr. Mullahy's summary of the major theoretical points very useful as background for reading the lectures.

Sullivan's basic conception involves the self concept, which consists of the "reflected appraisals" of an individual communicated by others to him. It is largely through the approval and disapproval of an individual's actions by others, as he pursues the goals of satisfying biological cravings and attaining psychological security, that the self is formed. Likewise, it is through this reward-punishment mechanism (reminiscent of the law of effect) that the activities, interests, and directions of the self are limited: "selective inattention" and "dissociation" largely based on anxiety are the processes described here. The infantile and childish tendency to accept events as "given" because they are incapable of much rational reflection or logical thought may carry over in greater or lesser degree to later life and play an important role in one's personality and adjustment.

The familiar emphasis on sex, Oedipus complex, etc., which characterizes many psychoanalytic publications, is lacking here. When Dr. Sullivan refers to psychiatry as the study of interpersonal relations, he means that human behavior may best be understood in terms of the kinds of interpersonal situations the individual has experienced. What these experiences were will determine the individual's handling of future such relationships, his mental health and adjustment, his happiness, satisfactions, and security. This is indeed a stimulating conception and merits serious study by all who wish to acquire understanding of human motivation.

CHARLES N. COFER
University of Maryland

STEPPINGSTONES TO ASIA

Bridge to Russia: Those Amazing Aleutians. Murray C. Morgan. 222 pp. $3.00. Dutton. New York. 1947.

IMPRESSED by the paucity of information on the Aleutians, where he spent a year in military service, Mr. Morgan was one GI who decided to do something about it. What he did was write this book, actually the first general, popular description of these remote and barren islands which he, unlike most of his companions, found interesting rather than dull or repelling. It is unfortunate that such a book was not available during the war. If it had been, or if the Army had even had the foresight to provide its men with such regional literature as did exist, morale would probably have been higher and the Aleutians might not have

been such a dreary experience for many of the GIs.

The book is divided into five parts: The Land, The People, The Sea, The War, The Future. In the first three sections, roughly two-thirds of the book, the author presents a factual but consistently interesting and well-written account of the islands and their history, from the period of Russian discovery to the beginning of the war. A brisk, informal, and often humorous style masks the large amount of careful research that went into the preparation of these chapters. The chapter on the war provides a vivid description of military operations and of Army life in the Aleutians. A topically arranged bibliography and a short appendix on place names, natural resources, and settlement possibilities conclude a book that should be of interest to the general reader, the student, and the many service men once stationed in the Aleutians.

HENRY B. COLLINS, JR.
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THE PLANT KINGDOM

Our Flowering World. Rutherford Platt. vii + 278 pp. Illus. $6.00. Dodd, Mead. New York. 1947.

THERE is a great gap between Mrs. Lincoln's botany of a century ago and modern plant science, which is becoming ever more precise and more deeply rooted in chemistry and other exact sciences. The opening of this gap was a prerequisite to development of the science, but with its opening came a distinct loss. Lost was most of the intimate feeling the professional and lay naturalists had for the living world that surrounded them. This feeling was in part a direct response to nature's beauty, to the perfection of nature's products, a realization of the vastness of the natural stage, and, after Darwin, an awareness of the ages-continued evolution that has produced the world of plants and animals. Some of what has been lost may be found in *Our Flowering World.*

This book is concerned mainly with plants and time, time in terms of geologic ages and time measured in sequences of dormant buds and their opening flowers and fruits. Its story is the tale of plant evolution controlled by, and reflecting, geological evolution. It begins with a brief description of modern plants. The reader is next taken back hundreds of millions of years and then returned to the present, stopping here and there along the way for a look at geological formations and their characteristic plants. Once more in the present, much is made of several seed-dispersal mechanisms and their physical operation.

Rutherford Platt is first and foremost an illustrator. His photographs are, as in his earlier works, superb. Several of his word pictures are hardly less so. His technique gives faithful representation of what is mostly northeastern vegetation. Further, it has all the selective lure of good portraiture. No one can read this book without a distinct feeling of aesthetic appreciation.

The author has worked into the book an important continuum of scientific data, theory, and hypothesis. There are some errors, a few misjudgments, and several omissions of fact. Were this book intended as a scientific presentation, they should be pointed out and their effects evaluated. It is perhaps better to accept Mr. Platt's Dresden-like panorama, with its romantic overglaze, as nearer to poetry and just enjoy it.

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MAN'S ENDLESS SEARCH

English Naturalists from Neckam to Ray: A Study of the Making of Modern Man. Charles E. Raven. x + 379 pp. $6.50. Cambridge, at the University Press. Macmillan. New York. 1947.

ALTHOUGH we often think of Aristotle as the father of biology, we do not as often remember that biology—or natural history—had many stepfathers. These are the men who brought the study of natural history out of the traditional belief in strange monsters and the improbable habits of imaginary beasts which was the "natural history" of the medieval mind, to the beginnings of

modern natural history with its reliance on observation and verifiable facts. This book tells the story of natural history's return to nature in England. This story of the transition from medieval bestiary to science might be repeated for Europe as a whole, for England was not alone in this development. The author well understands this, and, as his subtitle indicates, his book is more than a chapter in the history of science, it is a study in the enlargement of man's mental horizon, a phase of his endless search for a key to the harmony of the universe, which both literal theology and narrowly applied science deny. The synthesis is yet to be achieved, but its beginnings are in the Religio Medici of Sir Thomas Browne. This, the author declares in his concluding sentence, may well be the starting point for the quest for the *religio medici* of our own age.

Together with Dr. Raven's previous book on John Ray, this is a notable contribution to the history of natural history, and it is to be hoped that he will continue to follow the course of natural history down to our own time.

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Port Aransas

PISCICULTURE

Fish Ponds for the Farm. Frank C. Edminster. xii + 114 pp. Illus. $3.50. Scribners. 1947.

FISH culture in natural or artificial ponds is as old as history. Two thousand years ago the Chinese practiced fertilization of ponds to increase the growth of the vegetable organisms upon which fish indirectly depend. Their methods of stocking ponds with fish roe or young fish were quite efficient, as was also their plan of supplying additional food.

Centuries old, too, are the first published records of the practices followed in fish reproduction within the pond, the prevention of overpopulation by using predaceous fish to hold in check the multiplication of forage fish. In the early days of fish culture a much-used system consisted in taking as an annual crop all the fish in the pond by draining or seining and then restocking with eggs or young fish.

The author of the present volume reviews the evidence for a knowledge among the ancients of all the basic principles of fish culture, and proceeds to show how in modern times important refinements in the detail of methods have come into use, more especially in the United States since 1930.

Perhaps new methods of fertilization should head the list of these improvements. Chemical fertilizers (nitrogen, potash, and phosphoric acid) have replaced the use of organic materials. They are more sanitary and promote the growth of the minute plant organisms that constitute the natural food of animalcules and other small aquatic creatures upon which the forage fish (carp, breams, and the like) feed. This renders artificial feeding unnecessary. The author shows how this system furnishes a natural self-regulating device for the control of the fish population. There is a definite limit to the crop of fish to be expected in a pond of a given size. If it is too densely populated, the fish will be smaller and less desirable and will weigh no more in the aggregate than the smaller number of larger fish that will thrive in a limited population.

To this end the combination of large-mouth bass and bluegill sunfish, or bream, in the ratio of one to ten has proved most successful. In that proportion the bass feed upon the bream and prevent them from multiplying unduly, and, of course, the bass is a desirable, well-flavored game fish.

Mr. Edminster devotes a large part of his book to practical directions for selecting a site for the pond, the many engineering features of its construction and maintenance, and the variety of uses the pond may serve. Properly located, these ponds may supply water to domestic animals on the farm, in the open or by piping to the barn. If situated near the house, the water might be pumped through hose in case of fire. The pond may be looked to for swimming in summer, skating in winter or as a source of ice in the absence of other means of refrigeration, or for duck hunting in the fall.

Finally, the pond may become one of the

beauty spots of the farm, for family gatherings, evening siestas, or picnics, not forgetting its fish population, from which under proper care about 150 pounds of good eating may be harvested yearly per acre of pond area.

E. V. WILCOX

Washington, D. C.

BEYOND THE RANGE OF SOUND

Hearing and Deafness. Hallowell Davis, Ed. xv + 496 pp. Illus. $5.00. Murray Hill. New York. 1947.

THE objective of this volume—to answer the thousand and one questions of the layman about how we hear, the nature of deafness, and what can be done for it, as well as to provide an authoritative guide to all those actively concerned with the problems of the deafened—seems to have been successfully achieved.

The need for such a book has been accentuated with the increased consciousness of the problem that has accompanied new techniques for the prevention of deafness, the development of electric hearing aids, new operations and further advances in the field of education and rehabilitation during the war years.

In particular, the articles in the lay press in recent years have awakened new interest by their portrayal of the dramatic side of the new surgical operation suitable for one type of deafness. They have created a need for broader information to be made available to the laity, which this book supplies in nontechnical terms.

The chapters dealing with the physics and psychology of hearing, the structure and physiology of the sense organ, the explanation of the cause for various types of deafness, and the medical and surgical aspects of prevention and treatment, including the place of the fenestration operation, provide general basic information that can supplement the more specific advice of the otologist. They supply the answers to a host of questions that must be settled before the full acceptance and adoption of any electrical aid or a long-term program of education.

The sections on the various tests of hearing, the mechanical details of hearing aids and their selection, use, and care provide information of both a general and a specific nature that has hitherto been available only to a limited few. These sections should be a valuable guide both to those concerned with giving advice and to the prospective buyer of a hearing aid. The facts should do much to prepare him to get the full value out of his instrument.

One chapter is devoted to the organization of a rehabilitation center during the war; included in the discussion are medical and surgical care, auditory testing, fitting of hearing aids, auditory training, speech (lip) reading, and conservation of speech. In this, as in all chapters dealing with education and rehabilitation, the psychological aspect of the problem is given major consideration.

The history of progress in education of the deafened and the development of a more enlightened social viewpoint are reviewed. The training of the deaf child in the home and at school is discussed with a view to creating an understanding of the psychologic problems and providing a guide to various steps in education.

The various organizations for the aurally handicapped and for their vocational guidance are outlined.

This volume provides a reliable and much-needed source of information for the deafened, as well as a guide to all those concerned with the alleviation of the disability.

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COMMENTS AND CRITICISMS

SAN JOAQUIN VALLEY HOG WALLOWS

About twenty-five years ago a member of the staff of the Citrus Experiment Station, Riverside, California, who was investigating soil problems in Tulare County, wrote an article for the *California Cultivator* on the origin of hog wallows. In this he stated that the finest specimens of hog wallows in the state were in the Lindcove district, close to the foothills and about 13 miles east of Visalia. His idea was that the mounds were formed by clumps of vegetation holding wind-blown soil.

Because I was then, as now, living upon and working hog-wallow land and also writing occasionally for the *Cultivator,* I was much interested in this. A plant pathologist of the county, with whom I discussed the matter, did not agree with the above theory and thought that the mounds were formed by clumps of water plants catching and holding sediment washed down from the hills.

After this second theory was published in the *Cultivator,* a flood of letters and suggestions on the origin of the mounds came in, including all that were given in the article on Mima Mounds in THE SCIENTIFIC MONTHLY (October 1947) except that of their building by pocket gophers. If the mounds in the San Joaquin Valley were built by any mammals, it was evidently by ground squirrels, but even that seems more than improbable.

Neither the gophers nor the squirrels needed to construct mounds in hog-wallow land in order to find a place to live. Although there is much hardpan in hog-wallow land, it varies in depth, thickness, and quality, and there is always enough space above the hardpan for the animals to burrow in, so that the construction of mounds was unnecessary. Also, in former days, before systematic poisoning of ground squirrels was done, they gave no sign of building large mounds like these on flat or gently rolling land. Mounds where they do work lose their smoothness, instead of remaining round and smooth. The influence of pocket gophers on the shape of the mounds seems insignificant.

In fact, all theories for the origin of these mounds seem to have more faults than merits. None give satisfaction to more than a few individuals. The most satisfactory way around here to explain them seems to be that they are composed of material left over when Paul Bunyan built the Sierras long ago. That theory is more pleasing than accurate.

Nevertheless, there is a good deal of data by which we can approach the problem of the origin of these mounds. The local term, "hog wallows," is of course very misleading. In thinking of wallows one visualizes circular depressions in flat or gently rolling country, such as might be formed by animals wallowing in mudholes and causing them to increase in area and depth. Hog-wallow land is the reverse of this: it is composed of mounds, not depressions, sprinkled over fairly flat or gently rolling areas.

These hog-wallow lands have certain marked characteristics that should be helpful in studying the manner of their formation. The material composing them is reddish, indicating a fairly high iron content. This is true not only of the San Joaquin Valley hog wallows, but of hog-wallow land in other parts of California.

Next, and this is a very significant feature of the case, the soil neither expands on getting wet nor shrinks and cracks in drying, but retains its size and shape at all times. When dry in its wild state, it cements together like a brick. Incidentally, this causes the growth of vegetation on the mounds to be scanty, though grass may be abundant in the flat areas around the mounds. Raw hog-wallow land during the dry, hot summers thus appears barren and infertile. Actually, it is rich in mineral plant food and makes some of the finest fruit and grape country in the state when it is leveled, subsoiled, and irrigated. After a few years of irrigation and tillage, it often tends to become dark rather than red, and a stranger would not dream that it had once been covered with hog wallows.

The fact that the soil in these mounds does not shrink and crack on drying is one of the reasons that the mounds retain their shape. If they cracked on drying, the slopes would evidently gradually flatten and the mounds would disappear. Also, the fact that the material sticks together when wet and cements together when dry indicates that it was not brought into place by wind.

Incidentally, in much of this hog-wallow land, there are depressions here and there where ponds of considerable size form in wet seasons and endure, perhaps, for several months; the soil on their beds is a kind of adobe that cracks as it dries.

These depressions and the fact that hog-wallow land is often quite rolling near the hills suggest that the hog wallows did not form on a flattened lake bed, for then there would be no appreciable depressions in the land and it would not be rolling.

It is also worth noting that usually the more rolling the land, the larger the mounds. As the surface tends to flatten, the mounds tend to become smaller and lower. The fact that many hog wallows are on rolling land therefore suggests that it was not made by normal sedimentation, but that the material forming it was laid down in a hurry. Incidentally, too, water could never stand between mounds on rolling land as it is seen to stand between the mounds in San Diego County (p. 291, October SM). (The lower picture on page 287 shows how hog wallows often exist on rolling land where water drains off quickly.)

Another significant feature is the composition of the material of hog-wallow lands. In typical hog-wallow land here in Tulare County and the San Joaquin Valley generally, the soil proper is composed of very fine material in which there are con-

siderable sand, fine gravel, and even pebbles up to a good throwing size.

These pebbles seem to have had a varied origin in both composition and in movement from their original position. Some are well rounded by water, and some are uneven—friction has done little more than smooth the edges and corners.

Although the higher hills in this locality are mainly granite, many of the hills at the edge of the valley are of gabbro and related femic material, and the hog-wallow land seems to have been derived more from them than from the granite. The iron in it indicates this, also the high calcium and magnesium content. Many of the rough pebbles in the hog-wallow land seem to be made of magnesite, which has been mined in places in these hills. The gravel and pebbles occur both in the mounds and the land underlying the mounds. In the nature of the case, if the mounds had been made by wind-borne material, the pebbles would not be there.

The rounded and partly rounded pebbles, the sand, and fine gravel indicate deposit by water in some way or another; but the fact that these are well mixed with fine clay indicates that the material was brought into place as a whole, evidently at about the time that the land surfaces in these places took form. Patches of hog wallow on rolling land (p. 291, October SM) surely could hardly have been laid down gradually, on lake bottom.

The failure of every other theory for their origin, with the above-mentioned conditions, has therefore suggested to me the possibility that the mounds were formed by the uneven settling of considerable thicknesses of soft, unconsolidated material that was laid down hurriedly, but this provides no explanation of why mounds should form, or why they should take such well-rounded shapes if they did form in such settling. To the extent that this hypothesis has merit, it does little more than provide another unsatisfactory hypothesis for their origin.

As to their being built by pocket gophers, as has been suggested for the Mima Mounds of the Puget Sound country, this seems out of the question, for the hog-wallow mounds at least. Gophers live in such land, but give no sign of helping to make the mounds.

Mounds seem to exist only on certain kinds of land laid down under unusual conditions. From the pictures of the Mima Mounds in Washington, it seems unbelievable that gophers ever built mounds containing such large stones, or that they could do so if they tried. It seems probable that the origin of the mounds will always remain a mystery, though the cobbles of the Mima Mounds of Washington and of the hog-wallow lands of California indicate that rapidly moving water had much to do with the origin of both. The mounds of California retain their shape because the soil does not crack when dry, but cements firmly together. The soil of the Washington mounds may or may not cement together, but the size and number of the stones in them would nevertheless help to retain their shape.

DUDLEY J. WHITNEY

Exeter, California

TO AJAX

Dr. Carlson's article, "Science, Education, and the Future of Man" (SM, December 1947), dealing with a subject and a philosophy so important to all human beings, is couched in language that should be understandable by anyone who has progressed through the common schools of this American democracy. How can such a subject, presented in such convincing terms, fail to be of extreme interest to everyone? The great tragedy of it all is that the material presented by THE SCIENTIFIC MONTHLY trickles through only a very small percentage of our population. I find much in the journal of recent months that could well be made part of the general education of everyone if there were only some way of reproducing it a hundred thousandfold. If the A.A.A.S. could sponsor the distribution of such material directly to those owners and editors of American newspapers who are, or could be persuaded to be, sympathetic to popularizing the work of scientists, I feel a great mission would be launched.

Such scholars as Carlson, and correspondent Laurens C. Bolles (SM, December 1947, p. 526), who discusses "Back into Balance with Nature," are doing their part in furnishing information regarding the philosophy of scientists, a philosophy which shows that science can be really humane. But the distraught worker cannot, singlehanded, be his own Thomas Huxley to a whole world. Why should not the Rockefeller Foundation, or a similar organization, be interested in advancing civilization in some such manner as well as by the techniques it already employs?

C. ALLAN LYFORD

East Aurora, New York

MORE ON MAN, THE MYTH-MAKER

C. A. Muses in his criticism (SM, December 1947) of Read Bain's article on "Man, the Myth-Maker" (SM, July 1947) gives a rather novel definition of democracy as the "brotherhood of man itself." Apparently, this definition arises from the study of theology and not of political sciences, and its vagueness helps strengthen R. Bain's contentions.

The majority of the terms used in the liberal arts lack strict definitions. For instance, where are the dividing lines between aristocracy, democracy, and ochlocracy? How many persons, including some well-known historians, are able to differentiate between culture, civilization, and manners? Where is the border line between despotism and freedom or freedom and anarchy?

All types of governments are backed by elaborately worked out ideologies, but ideals should not be confounded with grim realities. Every nation has its own beliefs which, moreover, undergo continuous changes, and a person, or even a nation, is often persecuted because it is out of step with the stronger opponents. Unfortunately, the present age of narrow specialization witnesses the mass

production of experts at the expense of persons with encyclopedic education. This tends to increase the intolerance, as witnessed by the brutalities committed by the civilized but uncultured barbarians of the present age, who are decimating their opponents, in the name of freedom, humanity, and justice, at a much greater rate than has ever been done before.

C. A. Muses' uncompromising statement "that the overwhelming majority of scientists worthy of the name do not share the polemic and uncreditable aspects of the views to be found in Bain's article," may be regarded as an attempt to kill the development of free thought among scientists without resorting to any convincing argument. Imposition of such types of unasked censorship merely shows that quite a few persons are trying to force their beliefs on others by methods that can hardly be recognized as scientific.

V. A. KALICHEVSKY

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VITAL STATISTICS

May I direct your attention to an error, not too important, of course, but definite, that appeared in the December 1947 issue of THE SCIENTIFIC MONTHLY?

On page 447 the statement is made that the "Chicago Medical Society . . . is the largest county medical society in the country, with a membership of approximately 6,300. . . ." I should like to state that the Medical Society of the County of New York has a membership of over 6,500.

We have every honor and respect for the Medical Society of Cook County, but it is good to have the record straight.

I want to take this opportunity of thanking you for the enjoyment and education that I have had from reading THE SCIENTIFIC MONTHLY. I think that that magazine and *Science* are the most outstandingly enjoyable things that I get to read.

HAROLD B. DAVIDSON

Medical Society of the County of New York

VIVIPARITY

The paper by C. L. Turner, "Viviparity in Teleost Fishes," in the December issue of THE SCIENTIFIC MONTHLY was very interesting. However, I feel that I should register my objection to the definition Dr. Turner assigned to the word "viviparity." He used it "for all cases in which eggs are fertilized before leaving the body and are retained even for a short time."

According to this definition, a chicken is viviparous.

If a special name is felt necessary for the described condition in fish, it would be better to manufacture a new word rather than to give a new and contradictory meaning to an existing one whose definition is widely accepted.

Humpty Dumpty said to Alice, "When I use a word, it means just what *I* choose it to mean—neither more nor less," but for everyone to follow such a practice would lead only to confusion.

NORMAN D. LEVINE

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RE RHINE

I am discouraged! After over fifty years of experimental research, it appears from your reviewer's article on Dr. Rhine's book (SM, February 1948) that I must be ignorant of the first principles of scientific research; and perhaps my own work on solar radiation may be worthless.

I submit there never was a study of phenomena so elaborately hedged about with checks devised to shut out errors as that which Dr. Rhine describes.

When I first heard of the results, about twelve years ago, I firmly disbelieved them possible. To confirm my negative view I procured a set of the twenty-five ESP cards with record sheets. I determined to test clairvoyance by myself alone, so that I could not be deceived. After about two months' work, to my surprise, the chance was about 100,000 against one that I could have accidentally attained so great a success in my calls.

My experiments ran true to the forms that since have been many times reported. Success was greatest when the mind was fresh and happy. The record sheets showed greatest success in the upper left-hand quarter, and least in the lower right-hand quarter. At times of headache, tired condition, or depression, with neutral success for calls, there was strong positive result as between the call and the adjacent card. This displacement effect is now well known from results reported by the English experimenter Dr. Soal.

About ten years after the experiment on dice throwing at Duke University, the record sheets were received to tabulate the results separately for the four quarters of the record sheets (*J. for Parapsych.* **8**, 1, pp. 18–60, March 1944.) Such a test was not contemplated when the successful experiments were performed and their results computed. It was found *universally true* that positive results had been most accentuated for the throws recorded on the upper left quarter; next, and nearly equal, but less, for the upper right and lower left quarters; and least of all for the lower right quarter of the record sheets. This test eliminates all defects of the dice and all predisposition on the part of the experimenter.

The experimental basis referred to in Dr. Rhine's book now rests on the work of many years by hundreds of observers in scores of institutions, in many lands. I do not think this work can be brushed aside as it is done by your reviewer.

CHARLES G. ABBOT

Smithsonian Institution
Washington, D. C.

TECHNOLOGICAL NOTES

Largest technical college. Purdue University, like other institutions of learning, has had a great postwar growth. The enrollment of 14,000 is about double the former figure. The College of Engineering, with 8,000 students, is the largest technological school in the land.

Trying to go along as usual when conditions are unusual puts a good deal of strain on an institution and the personalities that make it up. Nevertheless, the methods developed by Dean A. A. Potter and Associate Dean W. A. Knapp to personalize education at Purdue appear to have enough flexibility to make the extraordinary expansion.

As first teacher in the college, Dean Potter keeps up on his pedagogics by personally teaching a senior class in power-plant design. Also, besides the administrative work with faculty members and university officials, he finds time to meet every senior personally several times during the year, and every student at least once a year.

Another course Dean Potter teaches seems to be unique in engineering education. It is a course for young instructors in the college. He believes that they should have some actual instruction in engineering education. The course is open to ten faculty youngsters who are working for advanced degrees. It covers the history of engineering education, methods, and curriculums in the United States and foreign countries, and the connection between engineering education and industry. The students do research on assigned topics, meeting in the dean's office to present their findings orally, and standing ready to defend their positions in discussion.

Teaching engineering instructors how to teach seems like such a good idea that you wonder why similar courses aren't given everywhere. Dean Knapp reports that the students like the course; it gives them a chance to express their views without being abashed by their elders, as would probably be the case in faculty meetings. The dean enjoys the course, too, although keeping ahead of such eager minds imposes a strain, particularly since it is not always easy to answer questions about traditional educational practices.

Subtle advertising. Releases from advertising agencies, no matter how technical the subject, usually make a pretty definite point of the advantages of the thing advertised. One recently received is different, to say the least. It is a sort of article on pipe, from ancient lead tubes—there's a reminder that the Latin word *plumbum,* "lead," gives us the word "plumbing"—to the modern underground transportation systems for water and fuels.

There is mention of Syrian baked clay pipe and of the copper tubes used by the Egyptians in 3800 B.C. Then come Greek and Roman aqueducts, and the hollow logs used up to one hundred years ago for water mains in England and America. (But there's no hint of the fact that holes chopped in the wooden mains and then plugged gave us "fireplug" to designate the hydrant for fire fighting.) Pipe fittings of malleable iron were first made in 1854 by Stanley G. Flagg, of Philadelphia—this mention of fittings and their importance in the business is about the only suggestion that the real purpose of the piece is advertising.

Dehydrofreezing. Dried fruits and vegetables are not as popular as frozen foods. A combination of drying and freezing may have advantages over either method of preservation, suggests the Western Regional Laboratory of the U.S. Department of Agriculture. First, a part of the moisture is removed, saving weight and bulk. The remaining water is frozen, breaking up the tissues less than if the full amount were present. The combination is called by the monstrous word "dehydrofreezing."

Engineering and geography. What engineers did in 1947 to improve transportation in various parts of the world is the subject of a National Geographic Society release. The report covers projects on the seas and in the

air, and on and in the earth. Riga, the Latvian city on the Baltic, is being rebuilt as a year-round port for Russian commerce. The Corinth ship canal in Greece and the Albert Canal in Belgium were opened for business. Despite civil war, China is at work on an 1,800-mile railroad line, and the Russians are building 2,500 miles of trunk lines across southern Siberia. Big airports are under construction; yet some of the planes are too big for them. Arabian desert pipe lines are as big as the "big-inchers" in the United States; the pipe is 30 inches in diameter to carry 300,000–400,000 barrels of oil a day.

Viking "Wineland." The Smithsonian Institution reports that study of the Viking sagas and comparison of the descriptions they contain with the shape of the earth as determined by modern methods indicates that the "Wineland" of the Norse adventurers was probably the territory near the mouth of the Merrimack River north of Boston.

Lightning center. What the General Electric Company describes as the world's largest laboratory for study of the behavior of lightning is scheduled for completion this spring at Pittsfield, Massachusetts. Two 5-million-volt impulse generators will supply discharges of 10 million volts—the pressure of natural strokes on transmission lines. These generators and other equipment to produce artificial lightning are expected to yield much information on the effect of Jove's bolts on electrical systems and how to achieve protection against them.

Cloud resources. When the General Electric team of Irving Langmuir and Vincent Schaefer announced the possibilities of triggering snow from cold clouds by dropping dry ice from airplanes, there was general interest and acclaim. Lowering clouds might be opened up near an airport. Clouds moving toward an urban center might be induced to drop their snow before they got to the congested district. Clouds that were about to escape the mountain ranges might be caught and their precious contents saved for irrigation. Rains might be induced—and some rains do, indeed, appear to have been touched off in Australia, our Western states, and elsewhere.

An interesting sequence to this scientific development is its legal complications. In the West a water claim has been filed on the clouds overhead. There is possible liability for causing unwanted rain or snow to fall, and also danger of accusations that land has been robbed of precipitation it would have received if the clouds had not been tampered with.

Threats of the law may prevent private experimenters from undertaking some weather projects. One of G.E.'s vice-presidents suggests that the development has great possibilities—as great, perhaps, as nuclear power—and it deserves study on an adequate scale, free from danger of legal entanglements. Mr. Schaefer has described the possibility of weather control as development of a natural resource.

THE BROWNSTONE TOWER

AT THE recent Chicago meeting 4,940 people registered with the A.A.A.S., the largest number yet recorded. The total attendance is unknown because many others registered only with affiliated societies. The meeting was probably bigger than any previously held by the A.A.A.S., and, though it is gratifying to those concerned that it proceeded as smoothly as it did, it is alarming to contemplate still larger meetings. The possibility of holding satisfying scientific meetings declines when the numbers of those attending exceed the optimum. Meetings like that in Chicago have probably passed the optimum and, indeed, can be held in only a few cities of this country. Many large hotels are required, and if the visitor wishes to meet individuals in different specialties and to attend meetings of different groups, he must spend much of his time walking or riding from one hotel to another and making his way through crowds. At the end he emerges somewhat exhausted and frustrated, having failed to see people he wanted to meet and to hear addresses that would have interested him.

When scientific meetings become numerically overwhelming, some action must be taken to reduce the attendance. The American Chemical Society, for example, will try a marathon meeting next summer. There will be an Eastern Session in Washington, D. C., August 30–September 3; a Midwest Session in St. Louis, Missouri, September 6–10; and a Western Session in Portland, Oregon, September 13–17. Thus, no one city will be overloaded with chemists, but those who are able and willing to attend all three sessions can do so.

The meetings of the A.A.A.S. have so far been held to practicable limits of attendance by the voluntary decision of more and more affiliated societies to meet separately. In my opinion, this trend is desirable both for the affiliated societies and for the A.A.A.S. When a scientist goes to a meeting of his professional society, he should devote his entire attention to it without being distracted by other events heretofore characteristic of A.A.A.S. meetings. On the other hand, he also needs the broader view and contacts to be obtained at A.A.A.S. meetings. The answer to the needs of the broad-minded specialist is obvious. Let him concentrate on his professional meeting at one time and expand his general knowledge at an A.A.A.S. meeting at another time. It remains for the A.A.A.S. to provide attractive programs for the inquiring mind. The conventional type of A.A.A.S. meeting, overweighted and unbalanced by concurrent professional biological meetings, does not provide the proper milieu for considering science as a whole. The A.A.A.S. should hold meetings of its own where current scientific thought and achievements may be synthesized, where broad scientific problems cutting across the recognized branches of science may be considered and brought to a focus. This, surely, should be a function of the American Association for the Advancement of Science. Perhaps the new Institute of Biological Science will replace the A.A.A.S. as the agency for arranging meetings of the biological societies that wish to meet together, leaving the A.A.A.S. free to develop unique programs of its own.

The Policy Committee that is planning the Centennial Celebration of the A.A.A.S. has boldly taken the step advocated above. The Committee has decided that neither sections nor affiliated societies will meet with the A.A.A.S. in Washington, D. C., September 13–17. So, for this meeting at least, the A.A.A.S. will stand alone while celebrating its Centenary. True, some of the biological societies will meet in Washington just prior to the A.A.A.S. meeting, but that is an advantage to those who may be able to stay over for the Centennial.

Previous meetings of the A.A.A.S. have included various symposia, but the Centennial meeting will be the first to consist exclusively of carefully chosen technical symposia and semipopular lectures. All partici-

pants will be as carefully selected as the subjects and will serve by invitation only. At this writing the program is tentative, but it is expected that the planned meetings will be held only on three mornings and four evenings, the afternoons being left open for visiting places of scientific interest in the Washington area and for making personal contacts. At last the pressure of an A.A.A.S. meeting will be relieved, and visitors will have time actually to visit, to think, and even to rest.

The first and largest meeting will probably be held in Constitution Hall on the evening of September 13. Here, let us hope, the President of the United States will give an address of welcome. The address of the retiring president of the A.A.A.S., Harlow Shapley, will follow, and the evening will be concluded by a reception.

On each morning thereafter five symposia will probably be held concurrently in as many different auditoriums. Here the visitor will get scientific stimulation, for each technical symposium will cut across three or more recognized branches of science. For example, on a given morning the visitor, in accordance with his interests, may attend one of the following symposia: World Natural Resources, World Health Problems, Nucleonics, High Polymers, or the Upper Atmosphere. He will hear three speakers, each active and prominent in research on some aspects of a general subject and able to present and evaluate current facts and theories—able, in other words, to erect a significant structure out of the building stones of research. The speaker, not being limited to ten minutes, but allowed almost half an hour, should be able to present effectively the results of his mature thinking on his subject. Other equally able men will be invited to discuss each paper, thereby emphasizing or throwing a different light on the conclusions of the speaker. The visitor himself may participate by submitting written questions to the speaker, who may take them up at the end of the session. Thus, quality will be substituted for quantity, and sound knowledge and understanding for the overwhelming details of previous meetings.

If the visitor should be fagged by the uncompromising scientific atmosphere of the morning symposia, he may relax at the evening lectures, where competent scientists will give interesting talks on subjects that would be suitable for the SM; for example, on bird migration, weather control, or mechanical brains. On each of these evenings he may choose among four lectures. At the end of the meetings he will go home scientifically and culturally refreshed.

The Centennial Celebration, we feel sure, will be well attended by out-of-town visitors. The importance of the occasion, the novelty of the program, and the location of the meeting in the national capital will combine to attract all the visitors that our hotels can hold. Furthermore, the meeting comes at the right time for most university scientists, just before the opening of the fall quarter or first semester, and one can drive to the meeting without facing the hazards of snow and ice so prevalent in the North during many of our Christmas meetings. What an opportunity for a pleasant and profitable vacation! So many people, I think, will be of like mind about it, that it would be well to make plans and reservations as early as possible.

We, of course, have made our plans for the Centennial (September) Issue of the SM. Instead of presenting a survey of science in Washington as we did for Chicago, we shall devote the Centennial Issue to contributions from distinguished scientists who have won the A.A.A.S. $1,000 Award. Thus, we shall have a notable scientific issue that will not only reflect one important aspect of the Association's advancement of science, but will be a tribute to the anonymous donor of the Award.

We are enthusiastic about all prospects here described and look forward to the Centennial Celebration with keen anticipation.

F. L. CAMPBELL